Canada Alberta

FOREST RESOURCE DEVELOPMENT AGREEMENT
ENTENTE SUR LA MISE EN VALEUR DES RESSOURCES FORESTIERES

Canada Alberta

The Canada–Alberta Forest Resource Development Agreement is a subsidiary agreement of the Canada–Alberta Economic and Regional Development Agreement, which provides coordination and cooperation between the governments of Alberta and Canada in areas of Alberta's economic development.

The Canada–Alberta Forest Resource Development Agreement is funded equally by the governments of Canada and Alberta, from April 1, 1984, to March 31, 1989.

Its primary objectives are to ensure the long-term availability of timber supplies; to optimize timber uses; and to contribute to the growth and diversification of Alberta's economy.

The Agreement comprises three programs: Reforestation; Applied research, technology transfer and opportunity identification; and Public information, evaluation and administration. These programs are managed by a joint Directorate and are implemented by Forestry Canada and the Alberta Forest Service.

L'Entente Canada–Alberta sur la mise en valeur des ressources forestières est auxiliaire à l'Entente Canada–Alberta sur le développement économique et régional, qui vise à assurer la coordination et la coopération des deux gouvernements relativement au développement économique de l'Alberta.

L'Entente Canada–Alberta sur la mise en valeur des ressources forestières est financée à parts égales par les gouvernements du Canada et de l'Alberta, et a cours du 1er avril 1984 au 31 mars 1989.

Ses objectifs principaux sont assurer la disponibilité à long terme de réserves de bois; optimiser leur utilisation; et contribuer à la croissance et la diversification de l'économie de la province.

L'Entente comprend trois programmes: Reboisement; Recherche appliquée, transferts de connaissances techniques et relevé des occasions; et Information, évaluation et administration. Ces programmes sont gérés par un Bureau de direction conjoint, et mis en oeuvre par Forêts Canada et le Service forestier de l'Alberta.

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ASPEN QUALITY WORKSHOP

Proceedings held
February 12, 1987

AT THE

ALBERTA RESEARCH COUNCIL

Edmonton, Alberta

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ASPEN QUALITY WORKSHOP

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OPENING REMARKS

Mr. Cliff Smith
Assistant Deputy Minister
Alberta Forest Service

Good morning, ladies and gentlemen. I'm particularly pleased to be able to kick off this workshop on aspen quality. There's no question in my mind that these seminars are very worthwhile. They pay big dividends, particularly when they're related to aspen, and judging by the turn-out you would agree with my opinion. Less than two years ago in Whitecourt, 1985, there was a very successful seminar sponsored by the Northern Alberta Development Council on the utilization of our northern hardwoods. I was unable to attend that particular seminar, but heard nothing but good coming out of it. I've been able to read some of the proceedings and some of the things that have taken place following that seminar, and I believe that it's been most positive.

On the other side, I have heard some people say that they don't believe that much has happened since that time, and I beg to differ with that opinion. Let's take a quick look at the track record in the short 20 months since that seminar was held.

A year and a half ago, Alberta's second, and Canada's second, oriented strand board plant was announced. That plant was recently completed and is now in production by Pelican Spruce Mills at Drayton Valley.

In support of that development, a new forest management agreement was entered into with Pelican Spruce Mills for the O'Chiese block southwest of Drayton Valley, and in addition, a number of deciduous timber allocations have been issued. The most significant aspect of that forest management agreement is that it's the first in Alberta that calls for both the utilization of the coniferous and the hardwood resource.

Following up, a few months ago Weldwood of Canada completed a major renovation to their Slave Lake waferboard plant. It is now an oriented strand board plant. It is most significant that the Company has taken a positive step forward in turning a marginal producer into what I believe is now a winner.

In support of that project, a new deciduous forest management agreement area comprising some 7,000 square kilometers and supporting a cut of about 300,000 cubic meters was entered into with the Company in the Slave Lake area in November of last year.

In the area of pulp, Procter & Gamble has continued to produce approximately 15,000 tons per year of aspen bleach kraft pulp, and in recognition of this, the Government and the Company have recently entered into an agreement which, if studies prove

feasible, will see major refinement to the pulping process to accommodate both the production of hardwood and softwood pulp at Grande Prairie.

Along the same lines, a significant announcement was made almost a year ago by Millar Western Industries to build a chemithermomechanical pulp mill at Whitecourt. It will be the largest of its kind in the world, producing some 600 tons per day. It will be largely based on the sawmill residual chips, but will also use upwards of a quarter of a million cubic meters of aspen per year.

Through all of these developments, utilization of the deciduous resource for oriented strand board alone stands at over 1 million cubic meters. Production of oriented strand board from our three O.S.B. plants totals well over half a billion square feet per year on a 3/8-inch basis.

Our total resource development will be approximately 2 1/2 million cubic meters per year, which is about 20 percent of our hardwood allowable cut. Our hardwood allowable cut is about 12 million cubic meters per year. Twenty percent may not sound like much, but just three or four years ago we were around 3 percent. I think we've made giant strides.

Another area that's exciting is the recent opening of the forest products panel testing laboratory here at the Alberta Research Council. The major emphasis is on hardwood resources.

In addition, there have been a considerable number of short-term forest product research-type projects which have been funded and have been successfully completed under the Canada/Alberta Forest Resources Development Agreement. This seminar is being supported under this successful program.

Over and above the primary forest products, there have also been some significant developments in the secondary field, and we now have the secondary products industry producing furniture grade lumber from about half a dozen facilities in the province. I'm sure that that's an area that's going to grow considerably.

Despite these positive achievements, we do have some major problems that we want to address.

First and foremost is quality. How do we determine if aspen trees on stump are of satisfactory quality and will be available for a particular project regardless of what it is? For those trees that aren't available, what do we do with them? What do we do with the inferior quality? How do we manage the resource if we don't utilize it?

Along the same utilization lines, many of our good aspen stands are currently underlain with great amounts of coniferous regeneration. How do we remove the aspen overstory without causing significant damage to the coniferous resource underneath? Can we utilize both resources in harmony? We believe it's possible, but obviously there has to be a lot of work done along the practical line in the field to make it feasible.

In the area of integrated harvesting, how do we ensure that where the aspen resource is being harvested the softwood growing amongst it is either utilized with it or is protected to the point that it will not be damaged or blow down. And vice versa, the utilization of poplar from our softwood and our mixedwood operations is equally important.

An ever exciting challenge will be the management of the land once the resource is harvested. Until now, reforestation in Alberta has largely concentrated on coniferous regeneration. We've been most successful. We have a track record that we're more than proud of in terms of the Canadian scene. But what do we do when we get into the mixedwood scene? Certainly many people think that if there's poplar involved that we'll do the easy thing and let it come back to poplar, and I'm not convinced that that's necessarily the right way to go. Obviously there's going to have to be a lot of work put into that aspect to ensure that we are managing the land base with the proper species and the proper overall end resource development.

Another major concern is the area of species identification. The utilization further down the road of black poplar and birch intermixed with our aspen stands is going to be a challenge, but up until such time as we are utilizing that resource, how do we properly distinguish between the aspen, the resource that we're after, and these other species? These are problems that we have to address, and I'm hoping that we'll hear lots about that today.

These are just a few of the things I see that we need to dwell on at this workshop, and I'm sure that you'll have many more. I'm hoping to hear good practical ideas at this workshop, and I would

hope that there will be lots of good dialogue because that's how we'll learn from each other.

On that note, I'll stop now because I certainly want to hear from the experts. I wish you all a very good workshop.

ASPEN DEFECTS: THEIR IMPORTANCE TO PULP AND PAPER

By
Mr. Dan Breck
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ABSTRACT

Aspen is one of Alberta's and Canada's greatest resources but the resource is of no value unless there's a demand for the end product. The demand and the prices that can be obtained must be in balance with the cost of utilizing the resource.

The use of aspen is experiencing major growth in the chemical pulping field. It's an extremely competitive field with quality the determining factor. The defect level in the aspen resource can directly affect whether the resource is economically viable in the pulping business.

Everybody in Canada is talking about the vast forest we have in aspen, and in the East there's some of the other hardwoods. We have to utilize these forests; take advantage of them. They are one of our greatest resources. But few people are looking at it from the point of view that the driving force for the utilization of the aspen is the marketplace, not the desire to go out and cut some trees and to push them through some type of a fabricating operation for the sole purpose of using a resource. The resources are of no value unless there's a demand for that product and that the demand and the prices that can be obtained is in balance with the cost of the resource. This has to be the primary point to keep in mind when you're looking at maximizing the utilization of the aspen resource.

Within the pulp and paper sector, we have two major areas of importance to Canada, and Alberta in particular. There is the kraft pulping process or the kraft pulping industry. We're talking about bleached kraft pulp, not unbleached grades and the newer grades that are coming into the forefront, the high-yield, chemi-mechanical pulps and their various cousins.

I'm not going to go into detail on what's happening to the whole industry, but in general the trends within the pulp and paper industry are towards the utilization of more and more hardwoods throughout the world. This is one of the reasons why some of the companies in Canada now are shifting some of their production from the softwoods into the hardwoods and also why almost all of the major expansion in the world has been in the pulping areas for the hardwoods. This is an area that Canada has an opportunity to capitalize on, but it's an extremely competitive field and it's one where quality is No. 1. If you don't have the quality to meet the various requirements of the marketplace, it doesn't matter how much pulp you can make, you're going to have a hard time selling it.

Within the chemical pulping area, generally, the aspen fiber would probably be ranked as No. 3 in the world from a quality basis. The number one fiber in the world is eucalyptus, the second is birch, and the third would be aspen in quality for paper and paperwork products. Southern hardwoods and some of the other species that have much less uniformity, and much poorer quality, follow in ranking.

The higher yield pulps is an area that is growing rapidly. Production is forecast to grow much more rapidly than demand, so there's going to be a tremendous amount of competition within the next two years. The areas that are growing fastest are those using

softwoods, but the long-term potential for these processes is in the printing and writing sector, which by today's experience requires and is best fed by the utilization of the hardwoods. Within this sector the aspen fiber is king. It is the best fiber for printing and writing grades from the high-yield pulp, thus the recent development at Millar Western. It's also the drive for a mill in eastern Canada that is working with aspen and a drive for another mill that is going onstream in British Columbia which may be able to utilize some aspen.

Now, I would like to dwell on the effect of defects in aspen on the quality of pulp and paper.

Since most of you are related to the solid wood products or the forestry area, you're familiar with the normal defects in aspen. Most of these are related to external form factors in the trees; knots, the tree form, crook, bulges, amount of butt swell, and damages that we see on the tree either through the logging operation or through some other type of damage through previous logging operations.

The other type of defects are those which are internal and this is what I'll address primarily. The defects we are looking at primarily in aspen are those related to attack by fungus, Fomes igniarius. It causes three problems to the pulp and paper industry: rotten wood, incipient decay where the mycelia from the fungus has just entered the fiber walls and has not created a tremendous amount of damage; and stain, which may be related to the fungus. There are also stains related to mineral deposits.

Within many conifers, it's very easy to tell if there is fungus or rot within the tree.

That's not the case in the aspen where the fungus will attack through any opening in the side of the tree. This is primarily through broken limbs where you have wind damage, or some type of scarring on the surface of the wood. This results in a tree that can have pockets of rot or pockets of defect.

In solid wood products there are some very definite effects of rot, stain, and incipient decay. Even a small amount can make the product totally unmarketable or of borderline value to the industry.

The pulp and paper industry is a bit different in that we're looking at a homogeneous mix of material going through the process. We're not looking at a 2 by 4 where one spot of rot in the middle automatically downgrades that piece of wood. We can have a certain amount of defect in our product and since it's a homogeneous mix, and as long as it's uniform, it may be acceptable.

From a technical view, the three types of defects have different effects on the pulp and paper industry. Mycelia tends to start attacking the lignin in the fiber wall. Within the pulp and paper industry, lignin is not necessary so if the fungus wants to eat up all the lignin and leaves the cellulose behind, we're quite happy. In fact, there are scientists that are looking for ways of getting the fungus to attack the wood and do the work for them.

After the initial attack or incipient decay where the fungus has just entered the fiber, and has eaten part of the lignin and some of the other sugars, we go into an advanced rot. The cellulose structure itself is now attacked. There are two effects: one is a reduction in the mass of material so that you're getting fewer pounds of actual fiber per cubic meter; and the second is that the intrinsic strength of the fiber is starting to degrade or reduce, and this has implications in the marketplace.

After advanced rot is total rot. Total rotted material is of no value whatsoever to the industry. In fact, it has negative effects as we'll see. The defects to the pulp and paper industry could cause three economic impacts. The first is increased manufacturing costs, and this comes by virtue of reduced yield in the chemical pulping area. If you're taking a rotten log to the mill, it's then going to be cut up into chips or whatever. If 50 percent of a log is cull the cost of the wood on a fiber basis to the mill is 200 percent over what the pulp mill buyer is anticipating.

The kraft pulping process is probably the most forgiving of any of the pulping processes. You could put almost any lignin-cellulosic material into kraft pulping and make pulp from it.

However, in all of the pulp and paper industry, garbage in is garbage out. You can do some things to the process that will try to buffer the effects of your raw material, but by and large the raw material dictates the quality of the pulp coming out. Again, the kraft process is the most forgiving. If you take a rotten log to a kraft mill, it's chipped. Because of the extreme amount of

force applied to the wood in the chipping process, most of the rotten wood will be turned into powder and be taken out in the screens. A majority of this material will come out in the screens and go off into a burner or waste disposal.

This means that the pulp mill has bought wood that has now had to be thrown away. It doesn't have a technical effect on the mill; it has a purely economic effect from the point of view of the mass that's bought and the mass that's recoverable.

In this gray zone between incipient decay and decay that's causing degradation of the material, there is some cellularization of the lignin. The wood goes into the process, the remaining lignin gets dissolved, and a lot of fiberous material is lost because it's already partially degraded.

This has two effects on the process: one is there's going to be a dead load to the recovery boiler. Most kraft mills are recovery limited. When a greater amount of decayed wood is included with the raw material to the boiler, less pulp is produced. The capacity of the mill actually decreases. That has very severe implications, especially if there is lots of rot. It's the top 3 to 5 percent production that the mill is able to profit from. If capacity is reduced at the top, profit is reduced.

Mechanical pulping is much more sensitive to the quality of incoming raw material. In the kraft pulping process, the stain is dissolved out so you can come out with fully bleached pulp of almost equivalent quality with sound softwood. Minor reductions in strength occur when large amounts of incipient decay is present in the pulpwood.

In the mechanical pulping process, defect affects the end quality in three major ways. First, if we're bringing in rotten wood, it's going to be chipped and much of this will be screened out, so there's a yield loss. If 10 percent rot comes out, that means the wood costs to the mill are 10 percent higher. Secondly, the stain and incipient decay that goes into the process consumes more chemical, both from bleaching chemical and from other materials. Bleaching chemical is extremely expensive.

Unfortunately, the mechanical pulping process is in its infancy in striving to break into the market. The entry fee to this market is a brightness level. We're competing against the

kraft pulps, and in order to be competitive, a brightness level of 80+ (ISO) is necessary. If you can't do this, especially in a printing industry, you cannot sell your pulp. It doesn't matter if you drop your price in half, you are going to have difficulty in developing the markets. So you have to have very high quality.

A significant amount of stain or incipient decay uses a significant amount of money to convert the wood into a product that is saleable; and secondly, if the amount of defect is high enough, you will not be able to obtain the levels of brightness that are necessary in order to sell the product in the marketplace.

You're paying to bring material to the mill which is increasing the actual wood costs to the mill; and if you are unable to sell the product, it will have to be downgraded significantly in order to get rid of it. Profitability is lost so using the raw material to begin with is questionable.

We come down to one of the major reasons for this workshop: How do we define the defect level? Most of you who are involved in forestry and wood products know that to say we have a certain percentage of rot, incipient decay, or stain is very difficult because of the variability of these defects throughout the log.

We also need to balance the costs and the penalties of using aspen in the process. This is where we have the greatest amount of work that's required. Referring to Figure 1 (page 15), if we go to the extreme and reject every piece of wood that has any stain, any incipient decay, or any rot, the cost of wood to the mill is going to be exorbitantly high. The cost per cubic meter is going to be way out of sight.

Likewise, if we go to the point where we accept any piece of wood the unit cost is going to drop significantly because we don't have culling. We can start going into whole tree logging. Our unit costs go down, but this may be offset by the reduced yield and increase in manufacturing costs. We see this in Figure 1. At zero defect you could give a pulp mill pure aspen. It is bright and I could get a premium price for it. I would have no difficulty in generating a demand that would require more and more expansion of industry within Canada.

As we increase the amount of defect, it's going to cost more to buy wood because I'm going to have to start culling more; I'm going to start losing more in the bush, in the pulp mill, and I'm

going to start adding more chemicals in order to try to get up to a 80 brightness level. There reaches a point where I cannot achieve the ante to get into the marketplace; the point at which I've reached an infinite slope, with cost becoming infinity, and I can no longer market a product.

These are the areas where we're having the most difficulty in defining what the cost benefit relationship is. There are many linear programming models that can be put together to define this. A fair bit of research is required to get these numbers. We're in an infant industry. We don't know what is causing some of the stain, the decay, and the reactions in the wood to peroxide; reversion with light after the product has been made is not completely understood. If we understood these relationships and we could quantify exactly what's happening and how to stop this reaction, we'd be able to provide very sound figures so that foresters and government could look at a resource and feel confident about its economic profitablity.

The economic curve is going to shift with time because in a very tight market with a shortage of pulp, the paper makers will take anything, but it cycles so that in months to come, an over-supply situation may occur and then you have to drop the price or have a much superior quality product. It's not a fixed number, it's a moving number relative to what the marketplace can accept.

That's as far as I'd like to go. If there are any questions that are more on the technical aspects, I'd be glad to answer that.

T. SZABO: Is some of what you have been mentioning also applicable to newsprint and liner board, or would it be somewhat different?

MR. BRECK: First of all, the liner board, no. Liner board is the lowest quality product you could make in the chemical pulping area. Aspen would not be the best product to go into liner board. You'd want to go into softwoods because you're competing on the international market and especially with the U.S. South which has a very good fiber for liner board. I wouldn't recommend that aspen be targeted as a liner board product. From an economics standpoint, I don't think it would be the best. But liner board doesn't need brightness, so the brightness that we're worried about in the mechanical pulp is not a factor. It's purely the yield; the same factors apply.

When you get into newsprint, the effects of stain, decay, and everything apply just the same as they do with the pulp. For example, at the Millar Western project, we're making a high-bleach pulp. The newsprint industry is increasing its demand on quality. A 54 brightness level was acceptable and now the southern standard is 56. Grades like 58 to 60 are going to be the norm soon. So if you start putting in wood that has a 52 and 54 brightness or 56 brightness and you're trying to sell a product that has got to be a 60 brightness, then you run into difficulties. However, it's much less severe because you can bring up three or four points brightness in wood with sulfides that are much cheaper than trying to hit the 80 brightness with peroxide.

The effect is still there, it's just where you are on the curve. You can accept more stain, but we know from the use of softwood that rot is very deleterious. Rot with certain hydrosulfide does not change brightness, and comes out as dirt spots throughout the paper. One thing that the paper makers or the printers will not accept is any dirt in their pulp; the same in bleach kraft, you cannot allow any dirt in that product.

MR. SMITH: Would you care to put any parameters on your curve? For example, in some of our potential aspen supply areas in Alberta, we know that the combined stain level is in excess of 30 percent. Do we already know, then, that those are out of the picture for CTMP, or should we assume that?

MR. BRECK: Yes, it can be assumed. However we must bear in mind, these are very rough figures. I've put them together for a number of products just to give an indication of the relative effect.

The impact of the stain is to increase costs, reduce brightness, and reduce selling price. I've tried to quantify it. Each 10 percent increases the manufacturing cost by five percent. What happens is that you're increasing the peroxide which takes about half of a percent to get rid of the bad stain.

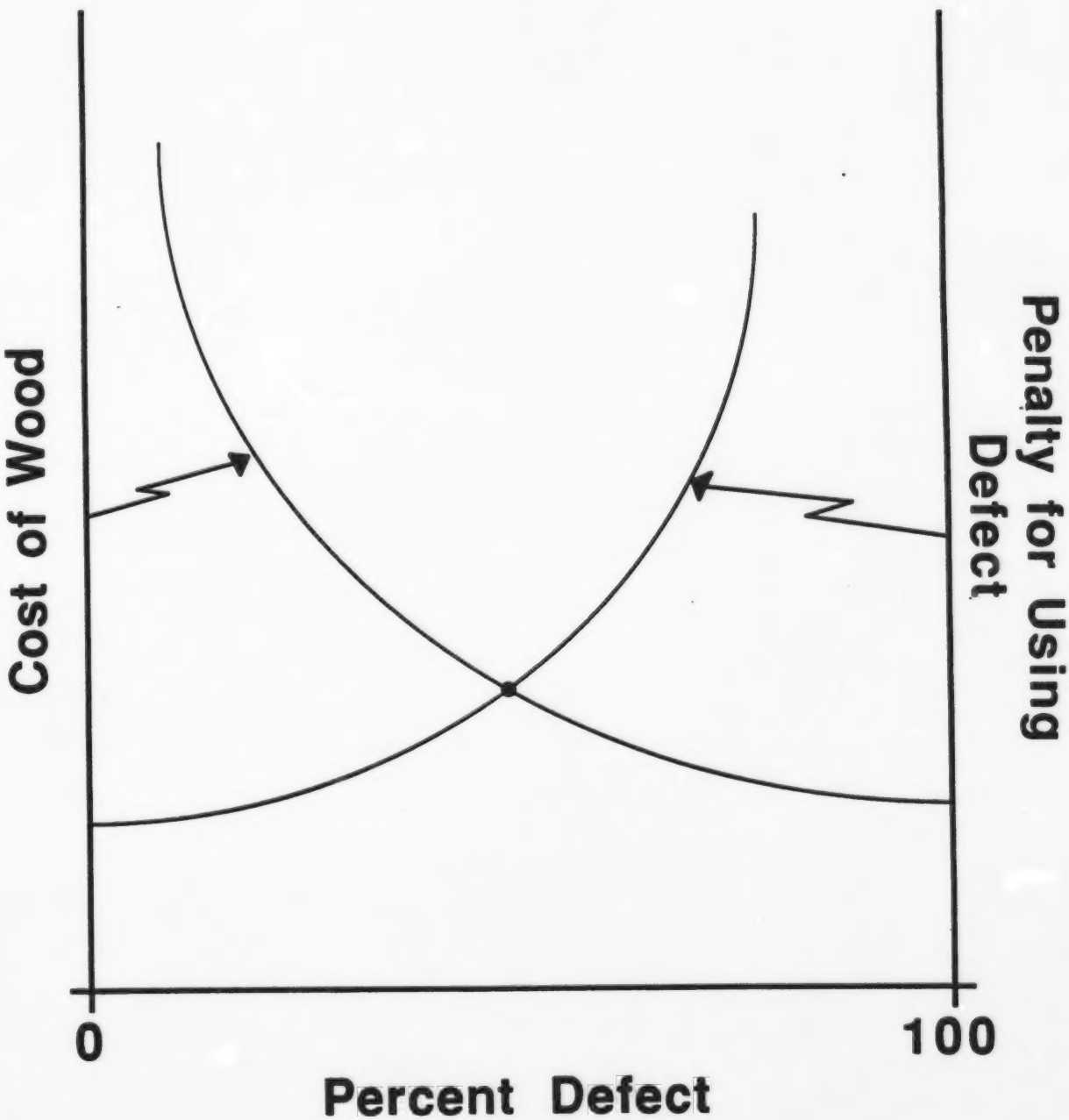
We know from laboratory studies that we can take up to about 20 percent total defect. I'm identifying total defect as stain, incipient rot, and rot. This is based on some of the studies that have been done in connection with the new Millar Western CTMP Mill Project. When you get that type of ratio, we want to keep the actual rot down to one or two percent that's coming into the mill and then you get some incipient decay and then the stain. I don't

know how you can scale a log and start separating between those two. It's very difficult.

We have run that type of wood, a mill-run material, through the pulping labs and know that we can meet 80 brightness at those levels. We know that it's costing us to do it but it's technically achievable. That means we can go into the marketplace without sacrificing a price on our product. But we also know that if we had zero defect, that we could get up to 85 and 86 brightness on that pulp and that the paper makers would immediately buy this product.

So 80 is an ante to get in. An 84 is the maximum that anybody has been able to make on a commercial basis. And we think that we can make an 84 and 85 brightness with the new process that we're putting in which means that we would be able to capture a significant amount of the market at a premium price.

FIGURE 1



BLEACHED CHEMICAL PULP

	Impact	Each 10% Increases Manufacturing Costs by (%)	Allowable % in Product
STAIN	No impact	0	Unlimited
INCIPIENT DECAY	- Reduces yield - Reduces strength - Higher boiler loading	2	N/A
ADVANCED DECAY	- Reduces yield - Higher chemical costs - Higher boiler loading	4	N/A

BLEACHED HIGH YIELD PULP

	Impact	Each 10% Increases Manufacturing Costs by (%)	Allowable % in Product
STAIN	- Increases cost - Reduces brightness - Reduces selling price	3	10 - 15
INCIPIENT DECAY	- Increases cost - Reduces brightness - Reduces selling price - Yield loss	5	0 - 5
ADVANCED DECAY	- Increases cost - Reduces brightness - Reduces selling price - Yield loss - Increased effluent treatment - Lower strength	5 - 7	0 - 1

MDF/PARTICLEBOARD

	Impact	Each 10% Increases Manufacturing Costs by (%)	Allowable % in Product
STAIN	None	0	No limit
INCIPIENT DECAY	- Lower strength at high levels - Poorer machinability - Poorer nail holding	0	20 - 40
ADVANCED DECAY	Lower yield	2.5%	0 - 5

ORIENTED STRAND BOARD

	Impact	Each 10% Increases Manufacturing Costs by (%)	Allowable % in Product
STAIN	Reduces appearance and marketability	0	20 - 30
INCIPIENT DECAY	Lower strength at high levels	0	20 - 40* 10 - 20
ADVANCED DECAY	Reduced yield	2.5%	0

* Technically OSB can contain up to 20-40% incipient decay. However, the market will only accept 10-20% incipient decay for aesthetic reasons.

LUMBER - CONSTRUCTION

	Impact	Each 10% Increases Manufacturing Costs by (%)	Allowable % in Product
STAIN	None –appearance may impact marketability	0	25%
INCIPIENT DECAY	- Reduced strength - Reduces grade	5	10 - 20
ADVANCED DECAY	- Reduces strength - Reduces yield - Downgrades product	5 - 10	0 - 10

LUMBER - FURNITURE, SPECIALTY

	Impact	Each 10% Increases Manufacturing Costs by (%)	Allowable % in Product
STAIN	Reduces aesthetics	-	0 - 10
INCIPIENT DECAY	-Reduces aesthetics -Reduces strength	5 - 10	0 - 10
ADVANCED DECAY	-Reduces aesthetics -Reduces strength	5 - 10	0

CHOPSTICKS, POPSICLE STICKS ETC.

	Impact	Each 10% Increases Manufacturing Costs by (%)	Allowable % in Product
STAIN	- Product is unmarketable - Yield loss	2 - 4	0
INCIPIENT DECAY	- Product is unmarketable - Yield loss	2 - 4	0
ADVANCED DECAY	- Product is unmarketable - Yield loss	2 - 4	0

PLYWOOD/LAMINATED VENEER LUMBER

	Impact	Each 10% Increases Manufacturing Costs by (%)	Allowable % in Product
STAIN	Restricts veneer to core	0	30
INCIPIENT DECAY	-Reduces yield -Reduces strength -Restricts veneer to core	2 - 5	10
ADVANCED DECAY	- Reduces yield - Reduces operating efficiency	5 - 10	0

SOME CONSIDERATIONS IN UTILIZING ALBERTA ASPEN FOR SOLID WOOD PRODUCTS

By
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ABSTRACT

The utilization potential of aspen and other underutilized species is experiencing more than passing interest for high value manufactured products. Today a broad range of items are being produced from aspen as clear wood products and sound wood products. But to achieve complete tree utilization, markets must be found for the low grade hearts of better quality logs and poor quality upper logs. A number of clear wood products and sound wood products presently manufactured in eastern Canada are listed in the paper.

Aspen can be extremely variable in quality. Recognition of visible tree-stem defect indicators can reduce errors in judging tree quality. Use of a tried and proven log grading system which has been developed using the National Hardwood Lumber Association (NHLA) Rules for factory lumber, can be a beneficial tool in bucking tree stems into optimum quality sawlogs.

Since the present system of grading aspen lumber is less than adequate in the NHLA Rules book, a few changes have been suggested which should improve its marketability and utilization.

The paper also discusses log making in some detail with direct reference to aspen. A number of recommendations are made and a list of guidelines are provided.

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[1]Previously, Hardwood Utilization Specialist with FORINTEK Canada Corporation and the Eastern Forest Products Laboratory.

Today, there is a greater awareness of the utilization potential of not only aspen but other species as well for high value finished products. For example, on a recent visit to Newfoundland, one furniture manufacturer was producing dining room furniture out of white birch. This furniture was given an African mahogany satin finish which, in my judgement, was as close to actual mahogany as one could get. Also, this same furniture maker was making kitchen tables and chairs out of locally grown eastern larch. This furniture had a natural satin lacquer finish and its beauty was beyond comprehension.

In Penticton, B.C., I understand that "easy to assemble" furniture is being manufactured from lodgepole pine and in Saskatchewan chop sticks are being made out of aspen.

Gentlemen, the number of potential products that are possible from our existing underutilized species and those species traditionally processed into construction lumber know no bounds. The few examples that I have cited here clearly show the accomplishments that are possible when entrepreneurial ingenuity is put to the test.

Now what about aspen? In preparing a partial list of products presently being manufactured from aspen in Canada, I have broken them down into clear wood products and sound wood products in order to accommodate material which would not yield the desireable size of clear-faced cuttings. The first group would be produced from clear defect-free wood, while the latter group would permit sound knots, worm holes, stain, seasoning checks which do not affect the strength of the wood and other sound imperfections. In this second category rot, shake, and splits would not be permitted.

Clear Wood Products	Sound Wood Products
- Factory lumber #2A Common and Better containing clear-faced cuttings	- Garden timbers
- Cut-to-size furniture components	- Crates and crating stock
- Molding stock and finished moldings	- Pallet stringers and deck boards
- Picture frame stock	- Fruit and vegetable boxes
- Louvered doors and shutters	- Electrical reels
	- Steel pipe support timbers

- Interior trim
- Glued-up furniture panels
- Unpainted furniture
- Kitchen cabinets
- Shelving
- Match splints
- Chop sticks
- Furring stock
- Lathes - snow fencing
- Log home timbers
- Expendable pallets
- Framing dimension lumber
- Pallet lumber
- Pallet timbers

All of the above products identified as clear wood products are produced from 4/4 or 1-inch lumber. A list of prices for some of these products are presented at the end of the paper as Appendix I.

In processing aspen, markets would have to be developed for material which would not qualify for No. 2A Common and Better lumber. This material would represent the hearts of better quality logs sawn for high-grade lumber and the larger and smaller diameter lower grade upper logs from tree stems. The low grade small diameter upper logs could be used as furnish for pulp, oriented strand board, medium density fibreboard (MDF) or waferboard, while the hearts of better quality logs (sawn for grade lumber) and the larger diameter lower grade logs would be considered for the sound wood products listed above. In producing sound wood products during primary processing, the emphasis should be on the production of timbers.

To better appreciate the discussions later in the paper on log grading and log making, I will now briefly discuss the grading of hardwood factory lumber as used by the National Hardwood Lumber Association (NHLA). First of all, it should be recognized that hardwood factory lumber is graded on a cutting yield basis rather than defect basis common to softwood construction lumber. This system of grading hardwood lumber considers for each grade the number, size and percentage yield of usable clear-face or sound cuttings in a board. By definition a clear-face cutting must have one clear face (ordinary seasoning checks admitted) with the reverse side of cuttings sound as defined in sound cutting. A sound cutting must be free from rot, pith, shake and wane. It will admit all the defects mentioned earlier in describing the general quality criteria of sound wood products except that restrictions are placed on the size of holes admitted.

According to the NHLA Rules, the following grade-names apply to aspen and cottonwood:

FAS
SELECTS
NO. 1 COMMON
NO. 2 COMMON
NO. 3A COMMON
NO. 3B COMMON

These rules specify that stain is admitted in all the grades listed. The rules also state that FAS, Selects and No. 1 Common take clear-face cuttings and No. 2 Common, No. 3A Common and No. 3B Common take sound cuttings.

The inclusion of stain in all grades means that when a board is dressed to standard surface thickness (i.e., 13/16 inches for 4/4 lumber), stain does not have to dress out. This obviously would be objectionable in clear high value products when given a light stain or natural finish. For this reason, in any sales agreement between buyer and seller it should be specified that stain shall not be admitted in the cutting areas. When this restriction is thus specified, stain can still be present in the cutting areas but it must dress out in surfacing a board to standard rough thickness (i.e., 4/4 inch).

A further point I would like to bring to your attention is the requirement that the No. 2 grade make sound cuttings. Since this is usually an important furniture grade the No. 2 Common should be broken down into No. 2A Common[1] and No. 2B Common. The No. 2A Common would require clear-face cuttings and the No. 2B Common sound cuttings. In addition, No. 3A Common and No. 3B Common should be lumped together as No. 3 Common as there is little demand for either of the grades individually.

With the above changes, the following grades should be used for aspen and cottonwood:

FAS
SELECTS
NO. 1 COMMON
NO. 2A COMMON
NO. 2B COMMON
NO. 3 COMMON

[1]Present industry practice is to grade No. 2A Common lumber from the better face. The reverse side of boards only have to be sound as defined in sound cutting.

The detailed specifications covering these grades are included in the appendices as Appendix II.

In my past work with aspen across Canada I have formed a number of impressions of its quality which I would like to discuss briefly. The first impression I have is that aspen can be extremely variable and unpredictable in quality. Some trees that contain interior rot show no visible exterior evidence. And, when extensive interior rot is present and exterior fruiting bodies are evident, most of the rot seems to be contained within the mid-length of tree stems. Fomes igniarius is usually the principle pathogen observed within this section of tree stem and is the most destructive fungus of all pathogens observed.

To recover high grade factory lumber from aspen, I look for trees with reasonably clear faces over part of the lower stem length. This zone should be free from visible branch knots, overgrown knots or other damaging imperfections. Early natural pruning of the lower branches seems to be the key in producing defect free lumber and reduced size of heart discoloration. And, if branches have been pruned when quite small, fungal attack seems to be setback because the small scars left by the pruned branches heal over quickly.

One 90-year-old open-grown aspen stand in Chetwynd, B.C., however, had branch knots clearly visible almost to the base of most trees irrespective of tree size. In stands such as this, quality of factory lumber would clearly suffer from butt logs. In another 60-year-old stand, located around Buffalo Narrows, Saskatchewan, butt portions of tree stems were clear of all visible exterior defects for about 12-14 feet in trees 14-inches dbh and larger. However, when sawn, the outer FAS and Selects boards were clear as expected but subsequent potential No. 1 Common and No. 2A Common boards contained worm holes. These insect galleries were ultimately identified as having been caused by power post beetle. Surprisingly, there was no outward evidence of entrance or exit galleries. This experience, in my view, points out the need to carry out some form of lumber recovery study in stands considered to be operational.

A tried and proven system of grading aspen sawlogs for factory lumber would be a beneficial tool in log making (which will be discussed later) and in segregating logs by quality classes. One Eastern sawmill has been sorting aspen by quality for many years in order to readily satisfy requests for the higher grades of lumber and other products.

The grading system provided in Appendix III has been used successfully on aspen. Its important variables in defining log quality are diameter, log position in the tree, face quality and scalable defects. The only adverse comment that could be made about the system is that it would not be applicable to stands where the largest diameter butt log is less than 13 inches as this is the minimum size for Grade 1 logs. And, for Grade 2, the basic minimum diameter for a butt or upper log is 11 inches.

As noted earlier, the principles of log grading can serve as a guide to woods workers to obtain the best possible log grades and hence lumber grades from each tree stem. This means that the minimum log lengths and small end diameters have to conform with the minimum lengths and diameters in the log grade specifications. The percentage yield, number and size of clear cuttings between log face defects must also be satisfied, including the amount of scalable defects specified for each log grade.

Past experience in bucking aspen has shown that upper logs less than 8 inches in diameter should not be produced. Usually, the uppermost part of the tree stem is quite crooked and totally unsuitable for sawlogs. It not only produces mainly No. 3 Common lumber but its lumber recovery suffers as well.

Since the length of clear defect-free stem in aspen is limited, butt logs should be cut random length 8 to 16 feet. This would ensure that logs would not be produced that contained portions of clear and defective stem sections as would be the case if only 8-foot logs were cut. By following the former recommendation, the volume of recoverable No. 1 Common and better lumber is maximimized in the longer lengths most often requested by buyers. In addition, markets for timber products would be more readily found if the longer lengths are produced. But, a word of caution, this is not an endorsement of long logs. Long logs made without regard to face quality and size can cause a reduction in log grade.

If a tree contains several Fomes igniarius fruiting bodies in the mid-section of a tree stem, an 8-foot butt log should not be cut on the assumption that most of the tree is culled. It is better to cut a 12-foot log and if its end is culled then reduce the length by jump-cutting. It should be remembered that not all rot has to be eliminated, especially if it is centered in the heart region and one or more outside full length boards are possible from at least two faces. In this situation, perhaps only 2 feet must be cut back leaving a 10-foot log which could be Grade 1. If it is cut 8 feet, it would only qualify as Grade 2.

In aspen, the most important log is the butt log. It is usually the only log in the tree that can be Grade 1 providing the top end diameter is 13 inches. The second log is often Grade 2 while the remainder of the tree stem can only make Grade 3 and Below grade logs.

There are numerous other recommendations and guidelines for producing optimum quality sawlogs and these are listed below. In some instances, some of the recommendations made earlier have been repeated.

1. Keep clear lengths in clear logs - especially the butt logs.
2. Do not cut logs longer than 14 feet unless the stem is perfectly straight, sound and the surface grade shows little change over its full length.
3. As tree diameter decreases, the length of butt log should decrease.
4. Do not contain scalable defect indicators in the middle of logs - eliminate these sections by jump-cutting.
5. Reduce sweep and crook by cutting shorter logs.
6. If possible, position overgrown knobs and branch stubs towards the ends of logs by adjusting log lengths.
7. Do not jump butt because of heart rot unless the end is totally culled.
8. Use the Humbolt undercut rather than the Conventional undercut.
9. Follow the log grade specifications in producing logs - this is the only way that both log grade and lumber grade can be maximized.
10. Lastly, exercise great care in producing the first two logs in the tree as usually they are the only quality furniture logs available.

It should also be emphasized that log lengths and diameter must relate to the products being sold. The final decision on how the log making should be carried out must consider the results of a marketing survey.

APPENDIX I

Primary and Secondary Product Values

FEBRUARY 1987

The following aspen price data have been obtained from a number of sources in Ontario and Quebec. Although these prices are current, they are mostly low because of present oversupply. Unless otherwise stated, almost all of the prices have been obtained from Ontario.

1. Factory lumber 4/4 K.D.

FAS	- $450 Mbf
Selects	- $430 Mbf
No. 1 Common	- $340 Mbf
No. 2A Common	- $250 Mbf
No. 2B Common	- $220 Mbf
No. 3 Common	- $170 Mbf

2. No. 2A Common and Better 4/4 K.D., 15% 2A - $425/Mbf
   Source - A large aspen producer in Quebec.

3. Garden timbers - $250/Mbf

4. Pipe support timbers - $220 - $240/Mbf

5. Pallet lumber or timbers - $180 - $200/Mbf

6. Furniture components, cut-to-size, kiln dried, rough, $785/Mbf*

7. Pallet components - $350/Mbf

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*This price has been estimated by taking the average price of No. 1 Common and No. 2A Common lumber and multiplying by 3. The factor 3 is a rule of thumb frequently used in the trade. It is a very conservative estimate.

APPENDIX II

Standard Hardwood Lumber Specifications for Trembling Aspen Basic Requirements

(1) GRADE[1]	(2) Minimum Size Board		(3) % Yield		(4) Fractional Yield		(5) Formula No. Cuts	(6) Max. Tot. No. Cuts	(7) Possible Extra Cuts	(8) Reg'd Units Multiply SM By		(9) Minimum Cutting
	Width (in.)	Length (ft.)	Basic	Extra	Basic	Yield				Basic	Extra	
FAS	6	8	83 1/3	91 2/3	$\frac{10}{12}$	$\frac{11}{12}$	$\frac{SM}{4}$	4	6-15 SM	10	11	4" X 5'
Selects	4	6	83 1/3	91 2/3	$\frac{10}{12}$	$\frac{11}{12}$	$\frac{SM}{4}$	4	6-15 SM	10	11	4" X 5' 3" X 7'
No. 1 Common	3	4	66 2/3	75	$\frac{8}{12}$	$\frac{9}{12}$	$\frac{SM + 1}{3}$	5	3-7 SM	8	9	4" X 2' 3" X 3'
No. 2A Common	3	4	50	66 2/3	$\frac{6}{12}$	$\frac{8}{12}$	$\frac{SM}{2}$	7	2-7 SM	6	8	3" X 2'
No. 2B	3	4	50	66 2/3	$\frac{6}{12}$	$\frac{8}{12}$	$\frac{SM}{2}$	7	2-7 SM	6	8	3" X 2'
No. 3 Common	3	4	25	--	$\frac{3}{12}$	--	--	Unlimited	--	3	--	1 1/2" wide and 36 sq. in.

[1] FAS, Selects, No. 1 Common and No. 2A Common must have clear face cuttings, No. 2B Common and No. 3 Common must have sound cuttings.

APPENDIX III

Hardwood Log Quality Specifications for Factory Lumber

Log Grades									
Quality Factors		F-1			F-2				F-3
Log Position in Tree		Butts only	Butts and uppers		Butts and Uppers				Butts and Uppers
Diameter (in.) (minimum)		1) 13-15	16-19	20+	2) 11	12+			8+
Length (ft.)	Nominal (minimum)	10+			10+	8-9	10-11	12+	8+
Clear Cuttings	Length (minimum)	7	5	3	3	3	3	3	2
	Number (maximum)	2	2	2	2	2	2	3	No Limit
	Yield (minimum)	10/12	10/12	10/12	8/12	9/12	8/12	8/12	6/12
Sweep and Crook (maximum)	Less than 1/4 of small end in sound defects	15%			30%				50%
	More than 1/4 of small end in sound defects	10%			20%				35%
Cull and Sweep (Maximum)		3) 40%			4) 50%				50%

1) Ash and Basswood 12" dib. for Grade 1 butts
2) All species, 10" butts Grade 2, if meeting Grade 1 specification
3) Logs otherwise Grade 1 quality, 60% cull permitted in Grade 2
4) Logs otherwise Grade 2 quality, 60% cull permitted in Grade 3.

REMOTE SENSING TECHNIQUES FOR FOREST SPECIES IDENTIFICATION A MINNESOTA - ALBERTA COOPERATIVE

By
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ABSTRACT

Forest managers in Alberta, Canada desire better aerial photography to identify hardwood species. In a cooperative exchange of ideas, Minnesota and Alberta remote sensing specialists are trying to develop this photographic tool. As a recommendation to the Canadian managers, this paper will outline the Minnesota Department of Natural Resources small format photography which effectively identifies hardwood species.

Minnesota resource managers use 35mm format photography to assist in effective management. Photography is produced in scales of 1:200 to 1:31,680. Optimal film types, photo seasons and scales are chosen to maximize the interpretability of the desired application. Applications include: 1) Species identification of vegetation; 2) configuration and acreage of management activities; 3) qualitative evaluation of plantations, herbicide applications, fire and windthrow; 4) seasonal events such as wild rice cover crop for waterfowl migration, water levels of lakes and rivers and insect or disease infections.

BACKGROUND

Minnesota resource managers have available to them 1:15,840 black-and-white infrared 9-inch contact photography. This photography is taken in the summer and flown on an 8 year rotation. However, it does not supply all the interpretive needs for today's resource management. As a supplement to this photography, a small format (35mm) aerial photography program can provide photos of optimal scale, film type and season in a timely manner. Small format photography can focus in on specific sites. Photography is a monitoring and data gathering tool beyond the capabilities of field checking. Managers have begun to rely on this tool as an alternative to some field surveys and also to make needed field surveys more efficient and accurate. Due to the limited staffing levels and project dollars, an alternative to field checking is necessary.

The State of Minnesota, Division of Forestry began a small format program following a University of Minnesota research project in 1976. This publication titled "A Remote Sensing Applications Program and Operational Handbook for the Minnesota Department of Natural Resources and Other State Agencies"* made recommendations for a remote sensing program. The Division of Forestry began a program with the objective to train field foresters to produce their own photography. In 1983, the program redirected its efforts towards a new objective. Under this objective, the field foresters give their projects to remote sensing specialists to produce the photography.

SMALL FORMAT PROGRAM

Equipment

A small format photography program requires a minimum of a properly equipped aircraft and a camera. In Minnesota the most common aircraft available for photo procurement is the Cessna 172 model with a porthole located behind the left front seat. This hole measures approximately 7 inches in diameter. F.A.A. approved mechanics can install these portholes at a low cost. Any aircraft

*Mark S. Jensen and Merle P. Meyer, "A Remote Sensing Applications Program and Operation Handbook for the Minnesota Department of Natural Resources and Other State Agencies", A Report of Research by the Remote Sensing Laboratory of the College of Forestry and the Agricultural Experiment Station Institute of Agriculture, Forestry and Home Economics, University of Minnesota, St. Paul, MN, 1976.

used should be equipped with an intercom system for effective communication, and a Loran-C system for accurate navigation along flight lines.

Cameras with 70mm format are another option for this type of program. The 70mm camera has had limited use in Minnesota because of the greater expense of the equipment and the lesser versatility of the film products for projecting and printing. New 70mm projector equipment would need to be purchased for each office to allow for this method of mapping. Both slides and prints are commonly produced for the user making 35mm more versatile. For mapping on base maps at specific scales, 35mm slides are used. The prints are used for stereoscopic viewing and as field copies.

Many brands of 35mm cameras are acceptable for aerial photography. Models should be chosen that fit motor drives. Several brands have models that accept a bulk film back allowing film magazines that contain 100-250 exposures. These cameras are desireable when projects include long flight lines.

Staff

Remote sensing staffs are desireable because specialists will be much more efficient and produce higher quality products. Less coordination of equipment and personnel will be necessary to accomplish the tasks. It was evident in Minnesota that when the objective of the remote sensing program was to train field foresters to produce their own aerial photography many personnel became frustrated and quality was often marginal. Personnel who only occasionally procure photography are out of practice and inefficient. Only a few individuals maintained an interest and continued to utilize the product.

A more effective program informs field foresters of the many applications available and trains them to formulate projects. Projects are submitted to remote sensing specialists for procurement. Participation is high and clients are very satisfied with the products. The remote sensing staff is able to coordinate operations to make greatest use of equipment, airtime and processing procedures. Product quality is superior because specialists make sound decisions in flight planning and performing the operations and specialized contractors are used to produce quality products.

APPLICATIONS

Most of the initial applications were designed using guidelines established in University of Minnesota research publications. One category involving several applications is seasonal analysis.

Seasonal Analysis

If a resource characteristic is seasonal or maintains a desired condition for a short time, a project must be planned to capture the condition. Several types of projects have developed to assist the resource manager to document these conditions. Species identification is one application from this category.

Species Identification

Species identification of forest vegetation is most obvious during two seasons of the year, spring and fall. Because hardwood species appear very similar on photography most of the year, peculiarities between the species must be capitalized upon when they occur. In Minnesota, managers can identify most species with strategically timed spring and fall photography. Aspen (Populus tremuloides and Populus grandidentata) is the most important tree species for forestry markets in Minnesota. Aspen is easy to identify during these periods which makes this photo product valuable to the resource manager. Examples of spring and fall photography are included at the end of this report to emphasize the capabilities of this photography for species identification.

Spring photography capitalizes on the leaves flushing at different times and their differing colours until the leaf has matured. During the flush and development of the leaves, colour infrared film will differentiate the species. The season occurs in May and lasts about three weeks. The photographing day in Minnesota is from 8:30 a.m. to 5:30 p.m. daylight time. This follows the guidelines for 30° minimum sun angle. A nine hour photographing day accommodates a production level of up to fifteen townships per day.

The spring season follows a chronological order with differing circumstances as leaf development occurs. Stage I - Trembling aspen trees leaf out about 1.5 weeks earlier than all other species and the leaves are green throughout their development. When these leaves have developed to a size which is

visible for aerial photography, then the photos will identify aspen from all other hardwoods. The other hardwoods species are difficult to separate because leaves are not visible at this time. Stage II - As the season progresses to a point where most leaves have flushed but are immature, the trembling aspen leaves are green and almost full size. Leaf development on the other species lags behind. The leaves are smaller and most species have coloration of yellow or red during development. Due to these variations, many of the species can be identified during this stage.

Fall photography capitalizes on the fall coloration of the hardwood species. This season allows the greatest number of species to be separated because color infrared film further differentiates the fall colors. The photographing day in Minnesota is from 10:15 a.m. to 3:45 p.m. daylight time for a minimum of 30° sun angle. This season occurs in September and October and lasts about two weeks, as long as the trees retain their leaves. Usually a single wind or rain storm will end the season by making too many leaves fall. This may occur early in the fall coloration period and make the season very short.

RECOMMENDATIONS FOR ALBERTA FOREST MANAGERS

In Alberta, Canadian forest managers have difficulty separating aspen from balsam poplar on traditional aerial photography. To better differentiate the species, an application which capitalizes on seasonal variation between species should be developed. It takes a year or more of constant surveillance from the ground and several test flights to develop photography to differentiate the species. Hopefully a variation that can be recorded on film will present itself. Any format of photography, 9 inch, 70mm or 35mm, should capture these differences on film. The important factor when trying to photograph seasonal applications is to create a system with equipment that gives the photographer the greatest flexibility. The program must operate efficiently when these short seasons occur.

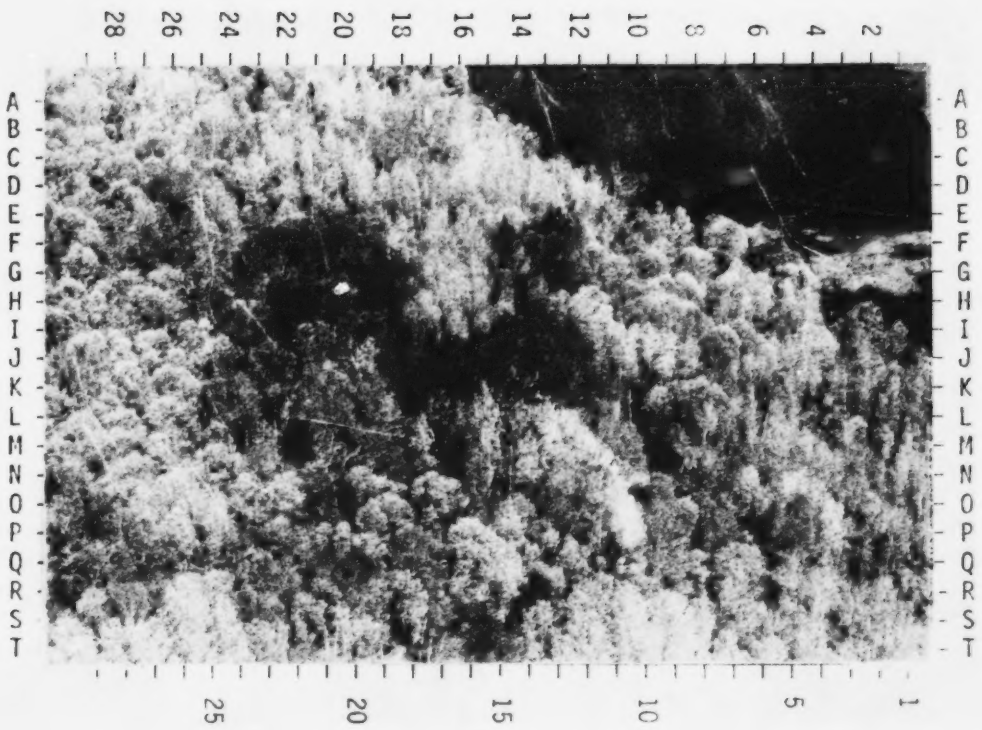

Figure #1: Spring season photography - Stage II. An oblique photo shows the coloration of the different species as the leaves develop. These differences can be captured on film.

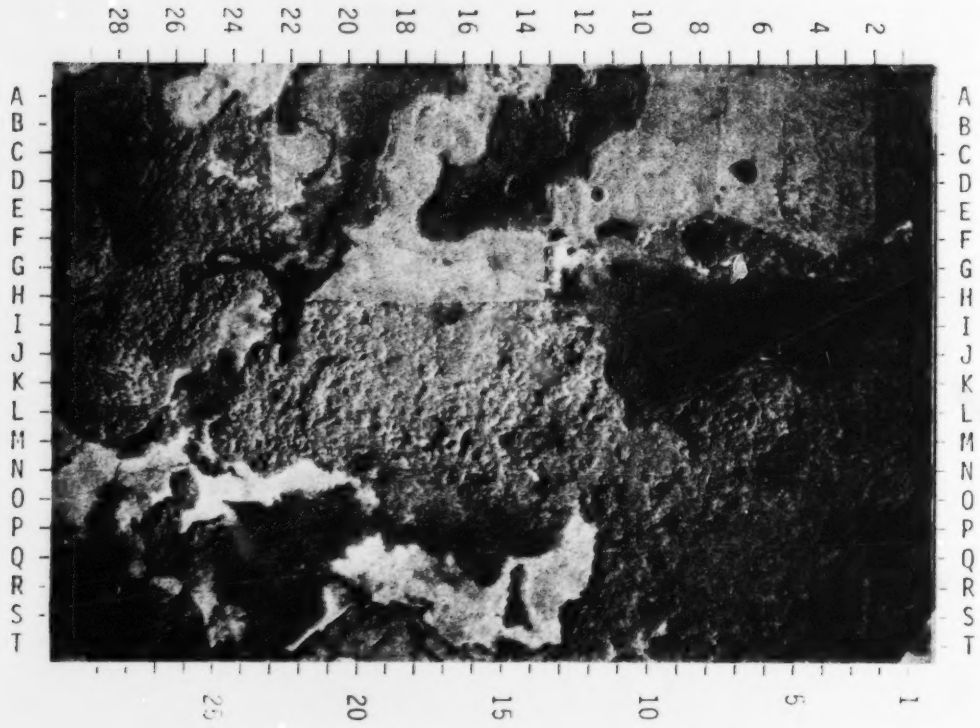

Figure #2: Spring season photography - Stage I. Film scale - 1:91,440. Print scale - 1:22,900 (on 5"x7" print, the scale is 1:15,840). **Aspen** (M-21, M-16) leaves are near full development and are red on the photography. **Oak** (J-16, Q-7) are in initial flushing stage. The leaves are only 1 inch long. **Black ash** (P-14, P-21) has not begun to flush because it grows in a wet environment. **Black spruce** (I-7).

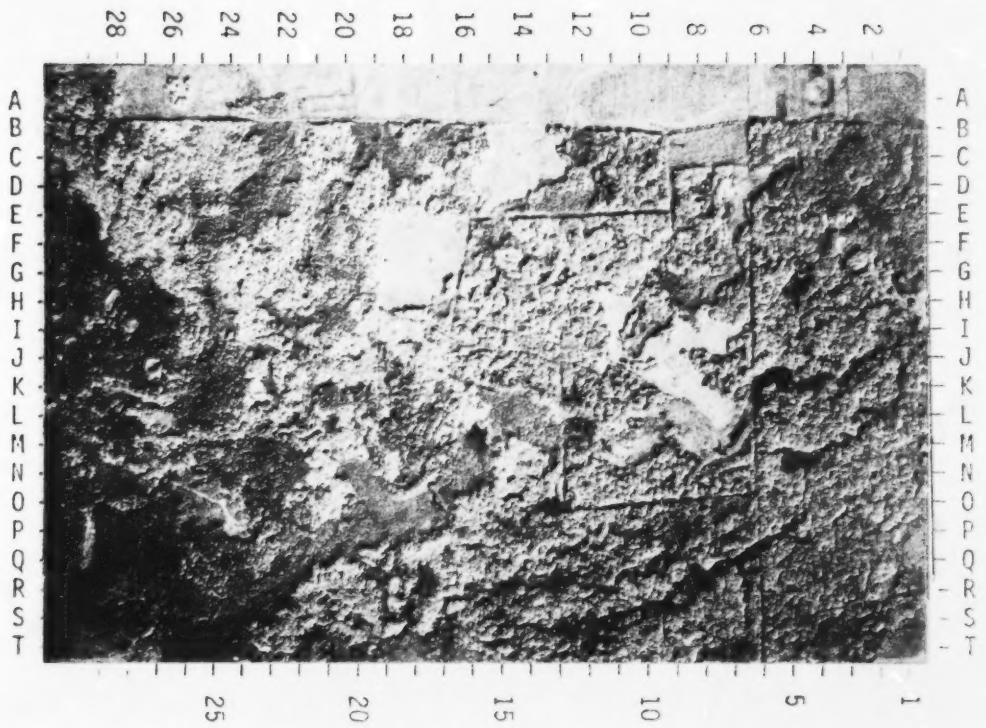

Figure #3: Fall season photography. Film scale - 1:122,450. Print scale - 1:31,680. **Aspen** (F-27, I-18) pink and red. **Black poplar** (Balsam poplar) (D-16, F-13, F-22) distinct white to tan. **Northern hardwood** (B-26) yellow. This type includes primarily maple and basswood, but can include oak. A high quantity of oak or an oak type would be copper colored. **Jack pine** (N-23) brown trees on upland.

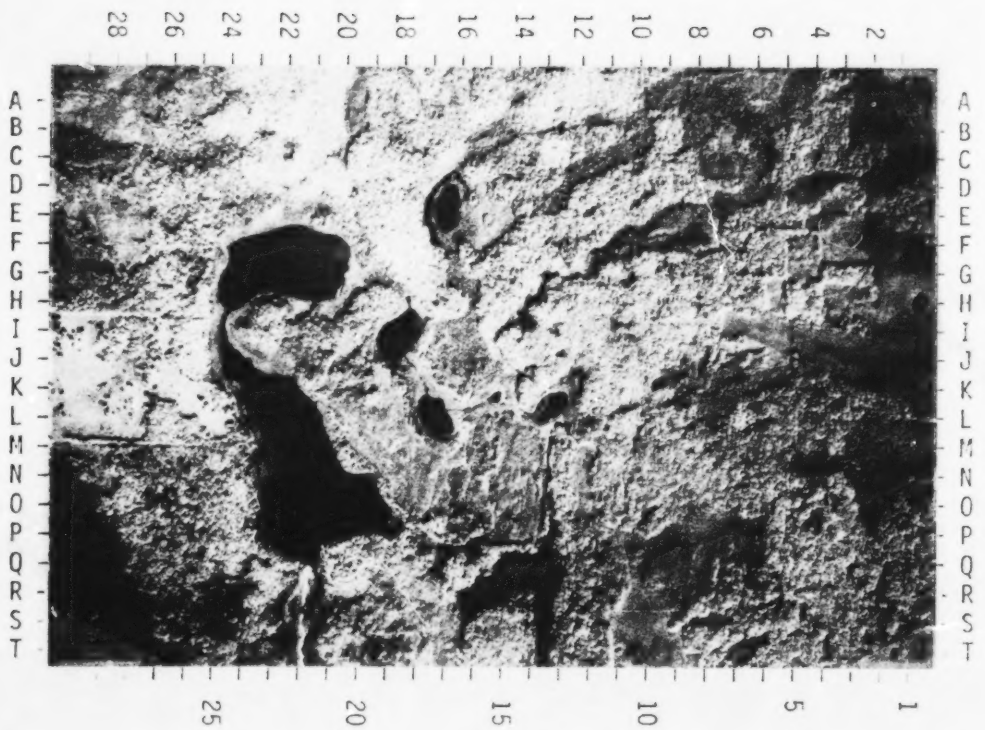

Figure #4: Fall season photography. Film scale - 1:122,450. Print scale - 1:31,680. **Aspen** (I-12, L-26) pink and red. **Northern hardwood** (B-22) yellow. Primarily maple-basswood. **Aspen saplings** (N-18, F-3, H-3) leaves have already fallen.

ASPEN DEFECTS: MANAGEMENT AND INVENTORY IN MINNESOTA

By
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ABSTRACT

In Minnesota, there are 13.7 million acres of commercial forest land of which aspen comprises 5.3 million acres. There are a dozen major industries plus numerous sawmills dependent on aspen.

Most management activities are limited to timber sales. Prior to the sale stands are prioritized from information gained through stand assessment inventory.

Older, decadent aspen stands are recycled by logging and shearing. Decay recognition in aspen stands is limited to conks with other indicators largely ignored.

OVERVIEW

In Minnesota, there are 13.7 million acres of commercial forest land, or land capable of producing in excess of 20 cubic feet per acre of annual growth and not withdrawn from timber utilization by statute or administrative regulations.(8)* Aspen is the major species in Minnesota, with the aspen type found on 5.3 million acres. Aspen accounts for 30% of the growing stock volume or 3.4 billion cubic feet and 24% of the sawtimber volume or 6.0 billion board feet. Approximately 83% of the total aspen growing stock is found in the aspen type with the other 17% in stands dominated by other species. Both quaking (Populus tremuloides Michx.) and big tooth aspen (P. grandidentata Michx.) are found in Minnesota, but quaking aspen accounts for 3.2 billion cubic feet of growing stock volume.

Non-industrial private landowners as a group own 42% of the commercial forest land, but the State of Minnesota is the single largest owner (19%). Both the federal, and county and municipal governments together, each own 17%, and the forest industry owns only 5%. The state owns 2.7 million acres, and 846,000 acres are typed as aspen. Sixteen percent of all growing stock volume on state land is aspen accounting for 551 million cubic feet, and 15% is sawtimber or 876 million board feet.

The 1977 statewide inventory did not measure volume losses and mortality by specific causal agents but recorded losses in broad categories such as insects, disease, weather, etc. Inventory results did show annual growing stock mortality averaged 1.2% of the total inventory or 141.5 million cubic feet. Losses due to diseases accounted for 57% of this annual mortality. Annual mortality of aspen growing stock amounted to 71.4 million cubic feet, and disease accounted for 63% or 45.2 million cubic feet of the total loss.(8) Since white trunk rot caused by Phellinus tremulae (Bond.) Bond. et Boriss does not directly cause mortality, losses due to this disease cannot be determined by this inventory.

Estimation of losses can better be made from stand assessment inventory on state lands. This type of inventory maps and cruises stands, and an estimation of the percent of stand affected by causal agent is made. Figures from the northwestern quarter of the state show an average of 18% of the total aspen volume is affected to some degree with white trunk rot as identified strictly by the presence of conks. This inventory also reveals that 76% of all aspen acres are damaged by some agent, and 52% of the damaged acres are from white trunk rot.

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*Numbers in brackets refer to reference list at the end of this paper.

There are a dozen major industries plus numerous sawmills in Minnesota dependent on aspen. Waferboard, hardboard, paper products and sawn products are produced. In 1985 the statewide allowable cut for aspen was 1.96 million cords, but the actual harvest was 1.65 million cords. This included 1.4 million cords of pulpwood and 100 million board feet (200,000 cords) of sawtimber. The unharvested surplus was 310,000 cords bringing the 9 year, uncut backlog to 6.65 million cords.(10)

Because much of the aspen originated during the same period of time and until the 1980's aspen demand was low, a great age imbalance exists. Approximately 2.6 million acres of aspen are below the rotation age of 40, and 2.7 million acres are older than 40 years.(10) The challenge is to capture the aspen resource before it deteriorates while at the same time store the resource on the stump long enough to regulate the age classes. Future predictions are for an increase in demand for the aspen resource, and this makes the age class regulation an even more critical objective.

MANAGEMENT

Prioritizing Stands

Nearly all management activities are limited to timber sales, except the U.S. Forest Service does carry out some limited precommercial thinning of high site index aspen stands. Before timber sales are made, stands are prioritized on state and county lands from information gained through stand assessment inventory. Presumably, the U.S. Forest Service and the forest industry also prioritize their stands for harvest. Prioritization of state and county lands are based on risk. Stands which are high risk due to age, condition, and site index are chosen for harvest. Stands with less decay and Hypoxylon canker, or younger stands are reserved for future harvesting. Age is probably the greatest risk factor since the paramount objective is to regulate the age classes by storing the resource on the stump.

Since many managers are faced with more high risk stands than can be harvested or sold, state foresters are trained and encouraged to use Anderson and Schipper's(1) method for predicting decay in aspen stands to further prioritize the high risk stands. This prediction method is based on the assumption that it takes approximately 6 years after infection to produce a conk. To implement this method, an initial cruise of the stand is made, and the basal area of the trees with conks is recorded. This basal

area is then multiplied by 1.9 to account for the decay that has not produced visible conks. Stands, then, can be further prioritized by the total amount of decay in the stand.

Timber Sales Procedures

State and County. Stands which are selected for harvest are cruised for sale using a variable radius plot or a fixed radius plot. Variable radius plot cruising is done with a 10 BAF prism or angle gauge, and fixed radius plots are usually 1/10th acre in size. Each 8 foot stick in the sample is recorded as a pulp stick to a 5 inch top or a sawbolt to a 10 inch top. An overall volume and bolt percentage is determined. The greater the percentage of bolts, the greater the value of the sale, and the easier it is to sell.

Minnesota Department of Natural Resources timber appraisal standards state that "defect (volume deduction) should be applied to sawlog (i.e., board feet) material only. Defect in pulp and bolt (i.e. cords) material will be handled by placing the defective material into the next lower product class."(5) Decay identification is usually limited to the presence of conks, and therefore a conk on a stick large enough to be cruised as a bolt would cause that stick to be cruised as a pulp stick. The greatest impact of decay is to lower the bolt percentage which will directly affect the value of the sale.

The general policy is not to cull pulp sticks even with obvious conks. However, the forester cruising the sale uses discretion in implementing this policy. The more experience the forester has, the more discretion he will use; he will rely on a measure of "gut feeling". Operationally, culling of pulp sticks does occur during cruising. Generally, a single conk will be ignored. Sticks with multiple conks will be culled by not counting the stick in the cruise. If the forester determines that stand appearance and area history indicate a lot of decay, both the stick with multiple conks and an additional "buffer" stick will be culled.

Another tool for accounting for decay is the use of price guide factors to adjust the base price upward or downward to try to better reflect sale and/or market conditions. "These factors, or spread points, indicate the expected profit ratio which influences the base stumpage price as they relate to each of the production costs and marketing factors."(2) There are a number of factors, but the one of interest is quality measured by soundness. The numerical value of this factor ranges between 0 for poor quality to

0.20 for excellent quality. This factor is added to the other 5 factors to arrive at a composite factor to multiply times the base price which then adjusts the base price upward or downward. The price guide factor for soundness is only one factor and does not have a great influence on value, but it is another tool to help the forester determine a more realistic price.

When setting base prices, local conditions can adjust the base prices to more accurately reflect those conditions. For example, the base prices for aspen pulp is $2.75/cord, and for bolts, it is $7.00/cord. But in northwestern Minnesota where market conditions are poor, base prices are set at $1.50 and $6.00 per cord.(11) These new base prices are then used on all sales in northwestern Minnesota, and these new base prices can be further adjusted by using the price guide factors.

Finally, the forester setting up the sale has the latitude to adjust the base price and the percentage of bolts beyond the price guide factors and the cruise results. For example, an area of aspen blowdown in north central Minnesota was sold for $.10/cord despite the price guide factors totalling to 1.00 (or 100% of the base price).(11) In this case the price guide factors determined that the aspen should be sold at base price, or $2.75 per cord, but the forester knew that the sales would never sell that high. His objective was to utilize the resource before it deteriorated and to remove the trees to promote regeneration of the damaged stands. The situation, then, set the price rather than the percentage of bolts and the price guide factors setting the price.

U.S. Forest Service. This agency counts every tree on the sale and measures a certain percentage of the trees. For each tree measured, the extent of defect is estimated, and then a percentage of the total tree volume is deducted. The percentage deduction is from a table which lists the percent of volume by 4 foot section for trees from 1 stick to 8 sticks. Deductions are usually rounded to the nearest 10%, and if deductions are less than 5%, no deductions are shown.

Ninety percent of all cull deductions in aspen are for decay, and decay is identified strictly by conks. When determining cull deductions, total cull length is a foot above and below the conk. If an 8 foot stick has 3 or more conks spread out 3 or more feet along the length of the stick the entire stick will be culled. A pulpwood stick must by 70% sound before it will be included in the cruise.(12)

Industry. Pulpwood used by the paper industry can have a higher decay percentage than pulpwood used by the waferboard industry. Since waferboard is now the major market for Minnesota aspen, the industry is more careful about the condition of the wood on the sale and the wood coming into the mills. Despite most of the pulpwood being weight scaled, industry foresters do pay careful attention to the amount of decay on sales they are buying. They primarily rely on conks to indicate decay, and rely on their experience to tell them what the conks mean. They use no standard method for cruising and determining soundness, but rely on the "gut feeling" method. They are very wary of the older age classes.(9)

The industry also relies heavily on contract loggers, and much of the wood is never seen by the industry until it is brought to the mill for scaling. If a load, whether tree length or in 8-foot lengths, has excessive rot, it will be rejected at the mill. Potlatch, for example, rejects 40 to 50 tons per month which is only about 1% of the total processed in a month's time. Most of the rejection, however, is due to crook, and it is not known how much of the 40-50 tons is rejected because of decay. Twenty percent cull on a load will reject the entire load. When weight scaling, cull percentage is figured from tables which list pounds per sticks by diameters.(9) Since all their wood is purchased in tree lengths, their estimations of decay are probably conservative because it is difficult to determine accurately the extent of decay when looking only at the ends of tree length wood. Champion's standards for their papermill states that they will only accept sound wood. Rarely do they enforce this standard, but fall back on using the standard to reject exceptionally poor quality loads.(15)

Aspen Recycling

Because aspen is a short-lived, pioneer species which regenerates by root suckering, it has been recognized for a long time that older, decadent stands can be recycled by logging and shearing. Shearing has been used for a number of years on a limited basis by wildlife personnel to attain a mix of age classes for deer and grouse. With the growing concern of age imbalances in the aspen resource, the growing importance being placed on the aspen resource by the industry, and the advancing age of the resource, it became clear that a program to recycle aspen stands was needed. It was estimated that 70,000 acres of state owned aspen could be recycled.(14) However, it took a faltering wood industry and a renewed interest in intensive wildlife management through habitat improvement to bring about an aspen recycling program in Minnesota.

In 1985 in response to the loss of a major aspen market in International Falls, the Minnesota legislature authorized an aspen recycling pilot program in northern Minnesota to help provide employment for loggers out of work due to the mill closure. Under this program, bidders could be limited to unemployed loggers. Ninety-eight sites on 2,027 acres were offered for recycling, and 71 sites on 1,262 acres were completed. Fifty-five applicants bid on the tracts, and 27 of them were successful bidders. The tracts could be sheared or logged. If logged, the trees could be skidded to a landing or dropped and left on the sale area. Average cost per acre for skidded sites was $138, and for non-skidded sites it was $76.(14)

One concern during this initial pilot project was how well would the aspen regenerate when all the trees were left on the ground. Fourteen no-skid sites, 5 partial-skid sites, and 12 full-skid sites were checked for first year regeneration and all appeared to have regenerated adequately. Sprouts ranged from 4,700 to 29,500 stems per acre. The average stocking percentage on the sites where no skidding occurred was 96%, and where skidding took place the stocking was 92%.(4)

In 1986, the Minnesota Legislature passed even more significant legislation when the "Reinvest in Minnesota Resource Act of 1986" (RIM) was passed. RIM's main purpose was to enhance fish and wildlife. Part of the enhancement effort is habitat improvement which includes aspen recycling. RIM was funded at $16 million for two years, and the aspen recycling part was funded at $1 million.

Bidding limitations under RIM are different from the recycling program of 1985. Instead of restricting bidding to loggers affected by the closing of the mill in International Falls, any resident of northern and central Minnesota is eligible to bid. The objective is to choose higher volume, overmature stands or stands with a high "production potential for the future."(4)

Criteria used to select stands(4) include the following:

1. The site must have a medium to better site index (SI 60+) where aspen is the preferred species to regenerate.

2. There must be at least 20 square feet per acre of basal area or 50 well-distributed aspen at or beyond the rotation age.

3. Stocking of desireable reproduction must be lacking or inadequate.

4. The stand is not saleable due to low volume, poor access, or stand deterioration because of age, insect, or disease problems.

When selecting stands to recycle, Hypoxylon canker incidence is also taken into consideration. If at least 25% of the stand is infected with Hypoxylon canker, the stand is not selected for recycling. The literature suggests that aspen stands with 25% or more infection may be genetically susceptible to Hypoxylon canker.(13) These stands then should be converted to another species rather than regenerating a stand which will have Hypoxylon problems in the future.

As of December 30, 1986, 49 tracks and 1,169 acres were under contract to be recycled. The average price per acre was $65. There were another 35 tracts involving 2,374 acres scheduled for bid openings during January.(4)

INVENTORY

In Minnesota there are two inventory systems which are referred in house as "Phase I" and "Phase II". Phase I is named Forest Inventory and Analysis and is a permanent plot inventory measured every 10 years. It is used to determine statewide areas and volumes, used to set allowable cuts, and used by the industry to assess the resource for mill expansions and new mill establishments. In 1986 another statewide remeasurement of Phase I plots has begun. Aerial photography is being used to photograph and assess the plots to reduce the number of plots to be ground checked. Phase II is a Cooperative Stand Assessment which is used to cruise and map stands on state and county lands. The results of this inventory provides information to the land managers for planning harvests and development work.

Forest Inventory and Assessment

Each permanent plot is made up of a cluster of 10 subplots. On each subplot a 37.5 BAF prism is used to tally the trees with each tallied tree being numbered, measured, and rated. Part of the tree rating includes placing each tree into a tree class, identifying the cause of damage or death, and determining cull volume. One category of tree classes is "rotten" trees. For sawlog size trees to be labeled rotten, "over one-half of the volume in the sawlog portion does not meet minimum log grade specifications primarily because of rot or missing sections." Pole

size trees are labeled rotten when the trees "do not have the potential to meet the log grade specifications for growing stock trees because of rot."(6)

If a tallied tree is damaged or dead, the cause is recorded. Aspen has a number of disease agents including Phellinus tremulae, Hypoxylon canker, Phellinus predominates with some Hypoxylon canker, Hypoxylon canker predominates with some Phellinus. The combination categories will reduce the accuracy of the volume loss determination strictly due to decay since the cankers will also contribute to volume loss, and the system is not sophisticated enough to distinguish between volume losses for each agent in the combination categories. It will give a better picture of decay, however, than not having any combinations, since inventory procedures call for labeling only the worse damage agent, and Hypoxylon canker would probably be chosen over decay. There would then be no way of knowing whether or not the tree was affected by decay.

Board foot cull volumes for sawlog size trees and cubic foot cull volumes for pulpwood size trees are calculated. "Board foot cull is the volume within the sawlog portion of the tree which cannot be recovered for use as lumber because of rot..."(6) Culling due to rot is done by determining the percentage of the useable portion which is unsound. If the portion with decay is less than 50% sound, the entire length of the rotten portion is deducted. If the portion with decay is greater than 50% sound, then only the unsound volume within the rotten portion is deducted. The length of the rot and the diameter outside the bark at the mid-point of the rotten portion are used to compute the cull deduction. Cubic foot cull deduction for pulpwood is made by 4-foot sections, and each section must be greater than 50 percent sound. Less than 50 percent sound will cull the entire 4 foot section. Cubic foot cull volume is recorded to a tenth of a cubic foot.(6)

Decay recognition by field crews is limited to conks. Other decay indicators are largely ignored. The standard field method of estimating extent of decay is to assume that decay extends 2-feet above and below each conk. For trees with multiple conks, the entire length of the portion with conks plus 2 feet on either end of the portion is assumed to have decay. To determine volume loss to decay, the inventory crew decides how much of the portion with conks has decay. This can range between 50% and 90%, and the percentage is determined by the appearance of the tree, stand history, and the experience of the inventory crew.(7)

Cooperative Stand Assessment

This stand reconnaissance inventory records insect, disease, or other damage by tree species in the stand. The inventory has the capacity of recording 5 species, 5 inches or greater DBH and 4 species less than 4.9 inches DBH. For each of these species, a damage agent can be recorded. For the main species in the stand (which is the species with the greatest volume for trees 5 inches and over, or the largest number of stems for trees less than 5 inches), the percentage affected and the percentage mortality are also recorded. Percentages are recorded by 5 categories of percentages, i.e., 1-10%, 11-25%, 26-50%, 51-80%, and 81-100%. Disease agents on aspen include white rot of aspen (Phellinus), Hypoxylon canker, Hypoxylon canker in combination with white rot of aspen, and heart rot.(3)

The percentage affected and mortality for the stand is the average determined by "adding the results from each plot together and dividing by the number of plots."(3) Operationally, inventory crews were to occularly assess the stand from each plot center and not just limit damage assessment to the "in" trees on the plots. They were also encouraged to look at the stand for damage while walking between plots. Damage assessment was a subjective determination.(7) Mortality was determined only on stems which were standing and taller than 4 1/2 feet, and only mortality occurring within 2 years was counted.(3)

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ASPEN CULL AND ITS SIGNIFICANCE IN BLEACHED KRAFT PRODUCTION

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ABSTRACT

Utilizing aspen efficiently and cost effectively requires an agreement on what part of the current resource is to be managed and an inventory knowledge of the available resource.

Quality is demanded in the marketplace and that demands aspen with low rot content.

We need to focus on a strategy that promotes wise use of the available aspen resource and sustainable growth.

I was asked to discuss the significance of aspen cull in the production of aspen bleached kraft pulp at our facility. With the knowledge that we currently have in that area, it certainly would be difficult to make more than one or two simple statements, and I suspect some of my fellow speakers are in the same boat. However, if we expand this topic of impact of cull to also include the answer to the question, "What other information is required about the aspen resource?", then I believe we will be focusing on all of the important issues.

Quite simply, rot, whether it's in softwood or hardwood, makes no pulp or poor pulp, as Mr. Breck did an excellent job of enlightening us on this morning. And our mill is no different than the general conditions he described.

Like most kraft pulp mills, our pulp mill is recovery boiler limited and we go to great lengths to protect the recovery boiler by a very elaborate screening system and also by continually working with all of the chip suppliers, our own wood room, our own sawmill, and all the others, to keep the fines in the furnish to a minimum.

The other point I would make is we are focusing on producing a very high quality aspen pulp. We don't believe our business is in what we call the junk-hardwood pulps. Of course, to make a high quality aspen pulp a high quality raw material is needed. Therefore, as resource managers, we need to know at what point in aspen stand development decay and defects start to reach costly proportions. The two graphs with the intersecting points that Mr. Breck used this morning to show the trade-off between quality and manufacturing costs is an excellent way of demonstrating this.

With that bit of background I would like to move on to the main theme of my topic. That is simply that we need to agree on what part of the current resource we should be managing and how much of it is there.

Managing aspen on the traditional cut-the-oldest-first sustained-yield policy or based on conifer utilization standards will stifle aspen development just as it's getting off the ground.

For example, at Procter & Gamble, we could not survive in the aspen pulp business with those types of management strategies, the ones that I referred to earlier about cut the oldest or using softwood utilization standards.

I believe that we need to be thinking of the best-use-of-the-land ideas. Ideas that were espoused by many of us, including ministers and deputy ministers, during the public hearings on agriculture. This same type of idea must be applied to aspen, and looking at what part of the resource to focus our attention on initially.

Certainly, the decision to give priority on a land base to either conifer or aspen cannot be made strictly on one general provincial rule that shows bias either way, to conifer or to aspen. We believe we are at the point in Alberta where reasonable decision making can occur based on specific areas, facility requirements, future growth potential, economics, resource description in the area, et cetera.

For example, let's look at where Procter & Gamble is with respect to aspen use today. I had described our situation today as the market-niche development stage. That's where we are. We believe we have the aspen to make specialty quality products in our current facilities that won't require massive infusion of new capital. It will require some [capital] to get the plant right but we believe we can do this without upsetting our ability to continue to make a very high quality bleached-softwood kraft.

As I said earlier, we believe that given our remote location, the very high freight costs to get our pulp to market, the only way to get into and stay in the aspen kraft business is to focus on a very high quality product. Today you can sell any kind of kraft pulp if you can get it out the door. Twelve to eighteen months ago, you were literally giving away poor quality hardwood pulps. There just was no market for it. And, of course, in those kind of conditions, you find you're not able to economically run your plant. You end up shutting it down and laying people off and that certainly isn't the way to run a business.

We're still working with our customers to satisfy their stringent quality requirements. We want to be in the high quality aspen business and we believe we can. We have proven on a trial basis that we have the potential to meet their high quality standards and are continuing to learn what aspen will or will not be successful in those products.

At this point in time we do have some defined needs identified, but I must caution you that these needs will remain flexible because we are still gaining knowledge and still learning. We know what works today and we're continuing to refine that process to have a better feel for what will work for the future.

In terms of quality, we know that pure aspen is by far the best, it should have a low rot content with a high proportion of stand age in the 60 to 80 and in some areas, 90-year-age class. Any older than that and there is too much decay and rot.

Generally, since aspen pulp commands lower prices than coniferous pulp, the delivered cost of aspen must reflect that aspen pulp earns less revenue than softwood pulp. Therefore, you need to achieve the highest yields possible from the aspen that you do deliver, and that means no rot. Nor can we afford to selectively merchandise aspen in the bush.

The cheapest way to log is by tree length and if the stems are rotten we have to leave them in the bush and go on and bring in the sound wood. Using aspen may lead to reduced year-round haul distances from our facility.

The information requirements that would be helpful to us in our particular circumstances would be as follows: good age class information, stand distribution data, a knowledge of the black poplar-aspen mix because we would like to stay away from the black poplar, accessibility of stands for summer logging, and of course, how much of the standing aspen is rot free.

This morning in starting the program off, Mr. Smith noted that we're currently using about 20 percent, or at least there are facilities on the board for about 20 percent of the aspen allowable cut. I would submit to you that in terms of useable A.A.C., we're significantly above 20 percent. I think, looking at our area, we certainly are.

To summarize, what I would like to see coming out of this seminar is that as a collective group of government, research, and industrial professionals we agree on the need for practical forest management strategy which focus on the material, either the aspen or the conifer, that we can use; that we focus on a strategy that promotes wise use of this available resource and sustainable growth in the forest industry in the future.

ASPEN UTILIZATION CONCERNS ASSOCIATED WITH ORIENTED STRAND BOARD PLANTS

By
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ABSTRACT

A current problem for Weldwood Canada is the aspen age class distribution and its relationship to cull levels. When harvesting in 100+ year old stands the traditional two-pass system for logging is not feasible. The high rot content in the aspen stands creates logging difficulties and increases overall costs.

I have been asked to speak to some of the concerns that we have at our operations with logging and with the oriented strand board mill (OSB).

Weldwood, as many of you know, is the oldest user of aspen in the province of those who are still utilizing a significant amount.

I think Mr. Smith mentioned this morning that this summer we converted to OSB which will certainly help to ensure the viability of our plant.

The current production levels enable us to use about 300,000 cubic meters of aspen a year. Our recently signed forest management agreement (FMA) last November will allow us to supply that amount of timber in perpetuity.

Our FMA is on the west side of Slave Lake and there are approximately 70-some townships (many over 7,000 hectares) for a total of 712,100 hectares of land involved.

We have a relatively unique problem with our land base. Our age class distribution is not exactly optimal (see Figure 1, page 64). There was approximately 20 years of cut at our levels in the 100- and 120-year age classes. You've heard some of the earlier speakers this morning talking about the quality of aspen of 100 years and up and it certainly doesn't help our operation at all.

The other problem is that in the 80-year age class, we have almost nothing. A little over two years' logging is all that's left in that age class.

The problem with the age class distribution is related to the reported trends in the decay of aspen. There is a great deal of variation encountered in various studies of the aspen resource around the province as to what happens with age and decay. The people in Minnesota said age is a concern, but age is only one of the factors, with site as the other, that affects the resource.

The aspen decay is so unpredictable throughout the stands and throughout the stems that it's very hard to assess what is actually in an area we're about to develop.

In some of the samples I have, you can see variable decay. One is an example of an 1860-origin stand where the rot entered through a branch that was 14 feet 8 inches above the ground. The rot went down about two and a half feet, stopped, and then the stem was absolutely sound to the butt. And there was another conk two feet above that which carried the rot about three feet upwards, stopped, and the top was sound. So it's very difficult to assess where the rot is.

If we use an average stand condition (Figure 2, page 65), this is from Dr. Dempster's report, you can see that once you get past 80 years of age, the aspen resource is very poor. Mr. Terry Barr just mentioned that for their process, it's difficult to use too. You can easily see that harvesting of aspen over 80 years of age will result in significant increase in the rot content.

Currently we're working on a two-pass system for logging where we log half the stand in the first pass and then we have to wait until the timber meets regulation height, perhaps 15 feet, for that area. In our opinion, once you get up to 100 years of age, a two-pass system is not feasible and we think we should be allowed to clear-cut those areas to create a young, healthy, and fully-stocked stand. In order to do that, the local management and district levels are going to require a lot of input from the Edmonton area.

I would just like to get into some of the other areas that in the field create a problem for us. The main problem is logging the aspen resource that has a high-rot content.

Wood costs are the only cost over which Alberta producers of OSB or waferboard have a lot of control. All of the other primary costs going into the production of board like resin, labor, power, we don't have much control over. We're at a disadvantage for our resin costs because resin currently comes from Ontario. Our labor rates, to be competitive in the province, are the highest in the industry in North America. And our power rates are some of the highest in Canada.

Figure 3 (page 66) is a summary of several of the deciduous timber permits (D.T.P.s) we have logged prior to gettirg into the F.M.A. The Forest Service ages on the left are not always correct, in our opinion.

The rot percentage ranges are great: 13.6, 22.7, 21.8, 7.5. High variation in decay shows the effect on the hauling costs. The

conversion factor, in kilograms per cubic meter, ranges from 852 to 1322 in these particular D.T.P.s with a cull percentage from 3.3 to 37.8 percent. The payload is a low of 17 in the summer to a high of 46.9 in the winter.

Net volume ranges from a low of 70 cubic meters per hectare at the mill up to a high of about 182 cubic meters. And I haven't shown or discussed our road or development costs but volume per acre has a direct effect on our road and landing costs.

One of the areas where we could desperately use some help is to get higher payloads, especially in the summer.

Our competitors in neighboring areas are able to haul approximately 37 percent more volume than us in the summertime with the same outfit. And in addition to being able to haul more weight, they are also given permission or allowances for tri-axles and quads which we can't have at this time. We have to go to bi-trains which in many areas are quite difficult to use in the bush.

Some of the areas we think could help with the utilization of the aspen resource such as ours, and some of these have already been mentioned, is an integrated conifer-aspen logging operation. That's coming along within the last few months and we're getting more and more cooperation with our coniferous cutters and the Forest Service to enable us to harvest those areas along with the coniferous operators.

As I mentioned before, we should be allowed a one-pass logging system and we should also be allowed a little more flexibility in long butting in the bush when the stand age reaches 100 years and the rot content 75%. The loggers have to long butt in two-foot increments even when they know there is rot which is a waste of time.

And as I mentioned recently, we require an increase in the summer haul weights that Mr. Terry Barr mentioned for pulp, in that they require fresh wood. We also require relatively fresh wood to create a good OSB product. I don't think many people realize that OSB and waferboard are engineered products and the quality control for engineered products starts with the waferizing. Rot still waferizes and comes through in the process.

Someone from Minnesota mentioned this morning that rot creates a lot of dryer fires. It also creates a lot of other problems for us.

In waferizing, the stained wood and the rotten wood does not cut cleanly. It shatters and forms a lot of fines that create dryer fires. Also the strand geometry is not as closely controlled as it should be, and it causes, among other things, poor thickness control.

We have to thaw our wood in order to waferize it in the wintertime and the rot acts as a [water] conveying system. In the summer the rot in the logs tends to soak up water more rapidly and creates additional energy requirements to dry that material.

Additionally, there is a lot of dirt, sand, and stones that become embedded in the rotten ends of the logs and this material severely affects the waferizer knife life in the plant.

Going along further in the plant, we get to our blending and forming. More fines require more resin and also create a change in the bulk density of the material. When these changes hit the line, control of the bulk density of the material is difficult.

Once it gets into the press, the rotten material tends to act like a sponge when the resin heats and flows and the wafers soak up resin rather than keeping it on the surface to create a bond. We waferized some of the rotten wood and made some boards out of it. We ended up with low internal bonds (IBs), as was suspected, but in addition, bending strengths were very low.

Strands made from rotten wood are so weak that even with a lot of resin, the wood structure is so weak that we end up with poor IBs, modulus of rupture (MORs), and modulus of elasticity (MOEs). The appearance of the board is not up to the standard accepted in the marketplace. Most of the people prefer a very light color and attractive board.

Once decay material gets into the plant, the only way we can adequately handle it is to screen it out on the rotary screens to take the fines out. Some of the material comes out in wafer-strand sizes, and this material won't screen out and ends up in the product. It's very difficult for us to take it out.

Figure 1

WELDWOOD FMA

AGE CLASS DISTRIBUTION
DECIDUOUS LAND BASE

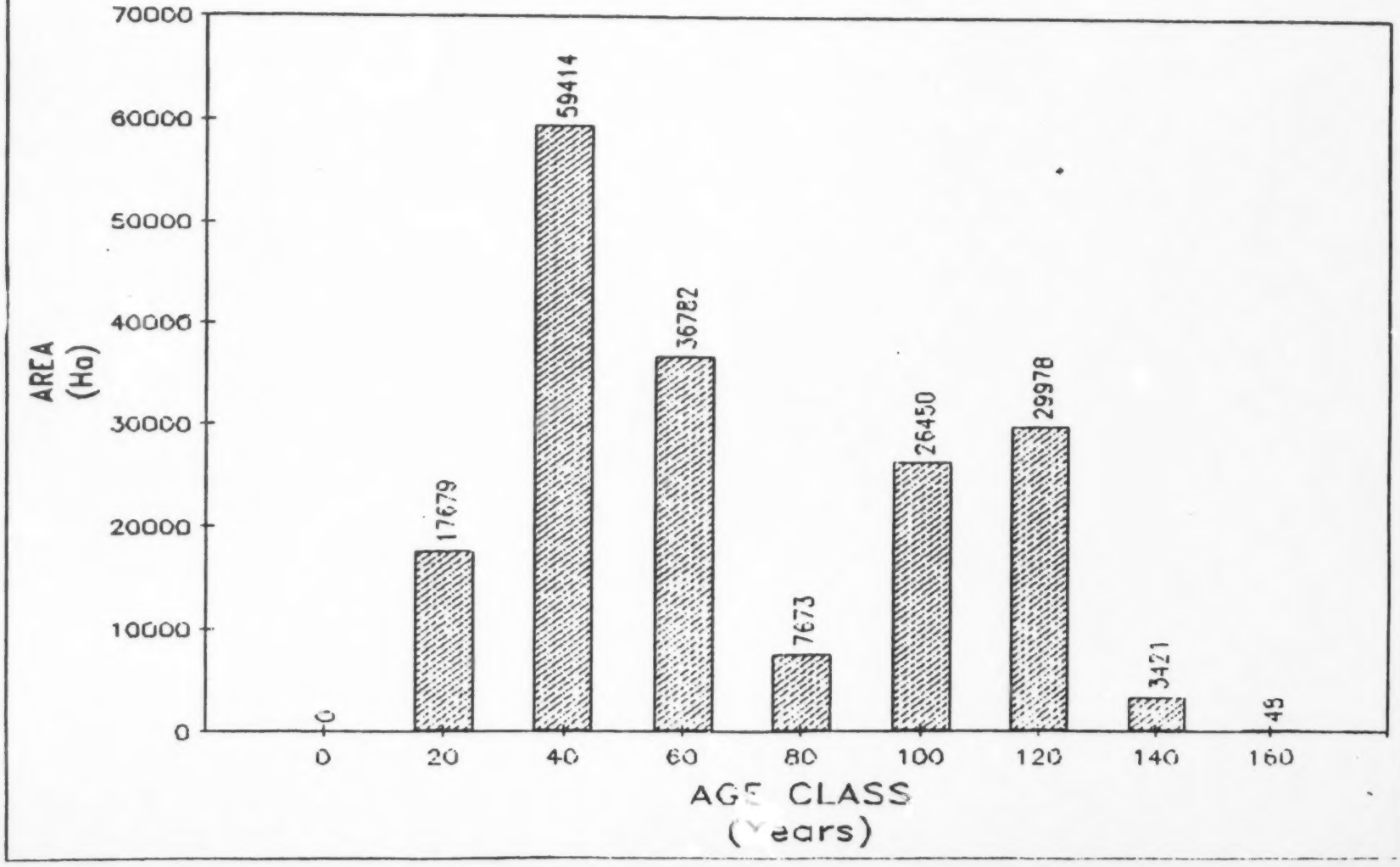

Figure 2

Percentage of Decayed Volume Predicted in Relation to Age for Aspen, Balsam Poplar and Birch

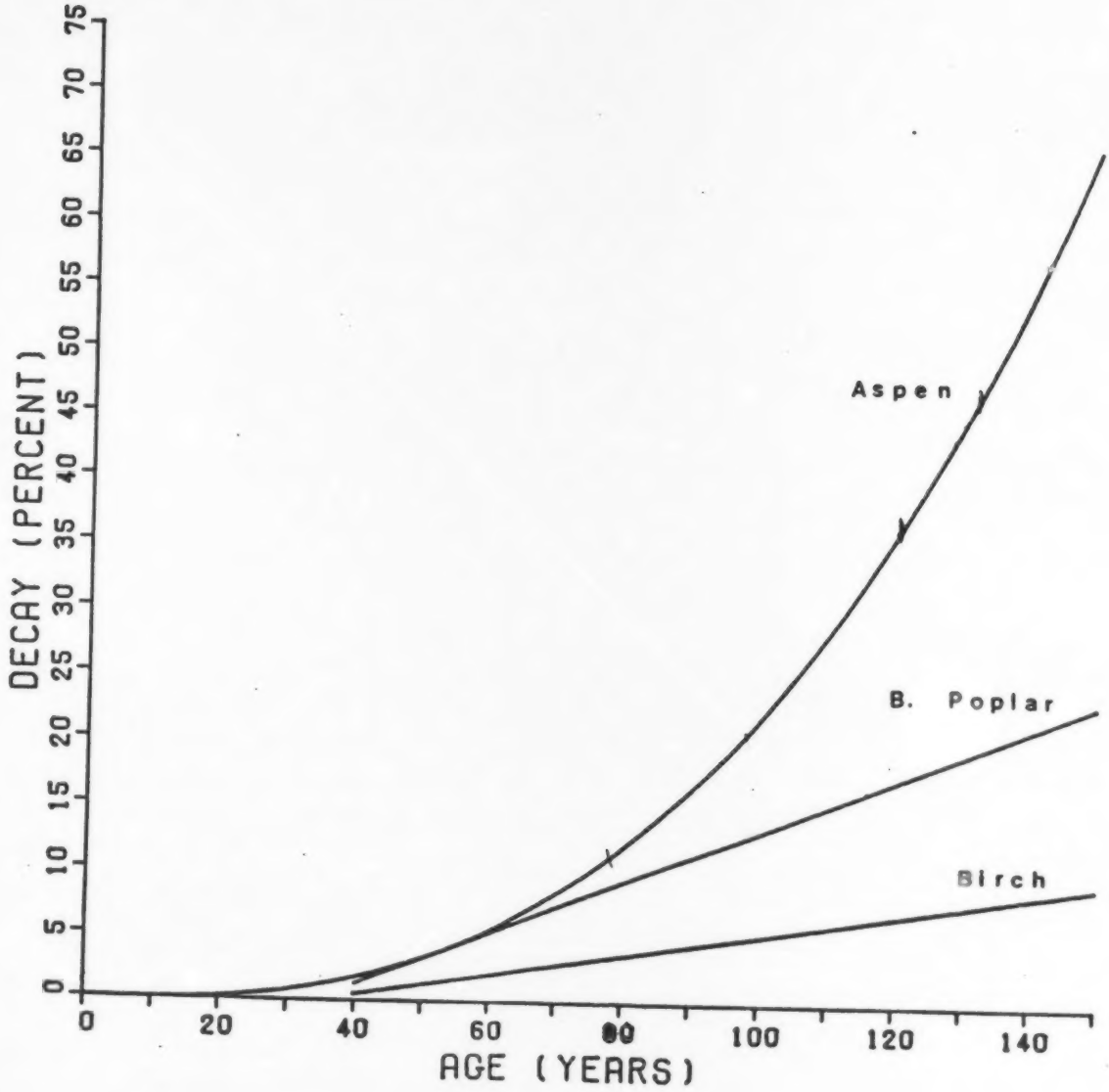

Figure 3

D.T.P.	A.F.S. AGE	STAND TYPE	NET VOLUME (m^3/HA)	AVE. DIAM. (cm)	PERCENT ROT	CONVERSION FACTOR kg/m^3	YEAR
SUMMER							
S05007	130 101 131 101	C3A-1/4 C3A5W-2/8 C4A'SW)1/8 C3A 1/2	107	23.0	13.6	1031.32 (N= 27)	85-86
S06001	101 141 121 101 141	D4A-1/8/85 B4A-1/8/85 C4A-2/8 C3A-3/8/86 C4A-1/8	134	28.3	22.7	1081.88 (N= 31)	
S05004 & S05006	109	C4A	85	25.5	21.8	1065.95 (N= 7)	84-85
S06002	89 99 89 99	C5A-1/5 D4A-2/5 D3A-1/5 C3A-1/5	182	18.5	7.5	930.43 (N= 9)	
WINTER							
S05002	131 121 101	C4AW-5/8 B4AWPb-2/8 B4AWPb(SW)3/1/8 C4AWPb(SW)3/1/8	108	28.7	25.0	1163.42 (N= 15)	84-85 85-86
S05011	120 91	C4AWPb-3/5 D3AW(Pb)2/5	135	22.3	11.5	1019.86	84-85 86-87
S05009	119 119 119 99	C3A(SW)1/3 C3A 1/3 B3A 1/6 C3A 1/6	124	25.5	16.6	1099.70 (N= 17)	83-84 84-85
S05003	118 98	B4A 1/2 C4A 1/2	70	27.9	16.6	1083.18 (N= 6)	82-83 85-86

ALBERTA FOREST SERVICE INVENTORY METHODS

By
Mr. David Morgan
Head, Forest Measurement Section
Timber Management Branch
Alberta Forest Service

ABSTRACT

The last major Alberta forest inventory was Phase 3, begun in 1971 and completed in 1984. Since the completion of Phase 3 the Forest Service has been looking for a type of aerial photography to facilitate separation of hardwood species.

The Alberta Forest Service is also looking at modifying methods of accessing aspen decay to better meet the requirements of CTMP mills.

Now that we've learned something of how hardwoods are inventoried and managed in Minnesota, a state where aspen has been considered to be a valuable resource for at least a decade, I'll bring this discussion more to bear on Alberta by describing how hardwoods are inventoried by the Alberta Forest Service.

The forests of Alberta have traditionally been inventoried during discrete time periods as the need for such inventories became apparent. The last major inventory, called the Phase 3 Forest Inventory, was begun in 1971 and basically completed in 1984. I will highlight two features of the Phase 3 Forest Inventory today, those of species differentiation and hardwood decay estimation. I'll begin with species differentiation.

The Phase 3 Forest Inventory was based on black-and-white modified infrared aerial photography, mostly taken at a scale of 1:15 000. That film was selected for its ability to emphasize differences between coniferous and deciduous tree species. When Phase 3 was begun, little commercial demand existed for deciduous species, so separating them was not emphasized.

In recent years, a rising demand for aspen has forced us to look for means of supplementing Phase 3. The most effective method used has been that of extensive field checking of stand species compositions, often done with the aid of a helicopter.

With the termination of Phase 3 we have begun to look for a type of aerial photography that would facilitate the separation of hardwood species. First the scientific literature and other forestry agencies in North America were consulted to ascertain what approach would most likely succeed here. Minnesota foresters were among those contacted. No one had a solution for classifying the mixed hardwood stands of central Alberta. We therefore decided to conduct a scientific test of likely alternatives to ascertain which would work best in the Alberta context. A trial involving three film emulsions (black-and-white panchromatic, color and color infrared negative films), four scales (1:5000, 1:10,000, 1:15,000 and 1:20,000) taken at two seasons (spring leaf off and summer leaf on) is currently underway. Fall color-change photography was also planned but the weather last year was unsuitable. Data from this trial is currently being analyzed. The results should be available in the near future. These will guide us in selecting aerial photography for future inventories and in how to supplement Phase 3. The results may also lead to further tests in future of smaller scales of photography.

The second feature of the Phase 3 Forest Inventory I will describe is the method used for estimating decay. To appreciate how decay estimates were developed some understanding of how stock and stand tables (called cover type volume tables in the Alberta Forest Service) were developed is helpful.

For volume compilation purposes, Alberta was divided into ten volume sampling regions (VSRs) based on a combination of ecological and administrative boundaries. Within each VSR, sample plots were established in selected forest types. Most of these plots involved crews visiting the plot location in the field to establish variable radius (prism) plots. The diameter at breast height (dbh), species, cull suspect class and height (measured or estimated) for each tree was recorded. The age of at least two plot trees was also determined with an increment borer. Four cull suspect classes were recognized: nonsuspect, old broken top, conks and punky knots, and scars and other wounds. Separation of trees into these classes significantly improved our ability to forecast decay levels. Much of the northern portion of the Province's forest lands is inaccessible, making ground plots difficult and expensive to establish. Large-scale aerial photo plots were therefore used to supplement the limited number of ground plots.

A subsample of both the prism and photo plots were visited on the ground to obtain measurements of individual tree volume, defect and age. After recording external defect such as sweep or crook, the plot trees were felled and sectioned at 0.3 m (stump height) and at 1.3 m (dbh) above ground level, then at every 2.5 m thereafter beginning at 1.5 m above dbh. Age and diameter outside and inside bark at the top of each section were recorded.

Where decay was found, tree sections containing the decay were subsectioned until the total amount of decay could be diagrammed. For each tree, total gross volume was calculated, in addition to estimates of potential sawlog and kraft pulp volumes based on the Alberta Log Rule. Single tree volume equations were developed from the gross volume estimates. These equations, combined with the defect calculations and previously collected prism and photo plot data, were used to compile gross and net volume estimates by forest type and VSR to five utilization standards.

The foregoing procedures were applied to all forest types, not just to aspen stands. Anyone who has worked with aspen will be aware of some of the unique problems associated with inventorying that species. Age determination using annual ring counts is difficult because spring and summer wood are not obviously different. False growth rings also occur. On older trees, bole

centres are often rotten, making age determination impossible. Sampling a representative range of stand conditions is often difficult as the range of combinations (particularly of ages) desired is often not present. For example, older stands may be difficult to locate.

A means for objectively and consistently separating decay into advanced and incipient stages is also required. Currently our crews use relative hardness; if a pencil lead can penetrate the decayed area it is described as advanced decay.

During and subsequent to Phase 3 localized cull surveys were conducted to supplement the inventory data base, usually in areas under consideration for mill establishment. We used these projects as an opportunity to assess the use of tree characteristics such as average dbh, age, height, number of conks and other features for estimating decay without felling the tree. The relationship of decay to age was also required for developing yield tables.

Unfortunately we found through regression analysis that the relationship between these various features and the amount of decay present was low, reflecting the tremendous variability in decay levels present in natural stands. The strongest relationship with decay levels was with number of conks, average dbh and age. Average decay trends were noted but such averages are deceptive as the range of decay at any age is high. No significant relationship between level of decay and forest management unit was detected.

We recognize that the informational needs of the forest industry are changing. We've already begun to modify our decay measurement methods to reflect these changes by recording stain (formerly ignored) as well as incipient and advanced decay to better meet the needs of CTMP mills. We'd like to be able to improve our ability to meet the needs of other producers as well, but first we must know what type and level of information is required. We hope that this Workshop will provide us with some of those answers.

APSEN MANAGEMENT PRACTICES IN ALBERTA

By
Mr. C. Henderson
Forest Superintendent, Whitecourt Forest
Alberta Forest Service

ABSTRACT

Long term aspen harvesting rights are issued by forest management agreements and deciduous timber allocations. Aspen cutting is authorized by licences and conducted according to approved annual operating plans. Currently harvesting is directed at pure aspen stands.

Cull in the decadent over-mature aspen stands is a major problem as is the protection of the spruce understory during harvesting of mature aspen stands.

I have been given the opportunity to review Alberta's management practices for aspen. From a reforestation point of view aspen is easy to regenerate. In fact aspen regeneration is so prolific it has incurred the wrath of coniferous-minded field managers. Site specific programs have been carried out to promote coniferous stand development. Should our management thrust be in this direction or should it be to utilize all our trees on the land base? Juvenile stand surveys show aspen is emerging as the most common tree in mixedwood stands. For example our juvenile stand surveys show 50% of Alberta reforested cutovers ten years and older are reverting to high-density hardwoods and another 14% to mixedwood. The range of hardwoods is 2100 [stems] to 4580 [stems] and some as high as 15,000 stems/ha. Timber Management is developing stocking standards for aspen and an appropriate regeneration survey. With aspen's natural regeneration success, I would like to devote the rest of my discussion to planning and harvesting practices.

Long term aspen harvesting rights are issued by forest management agreements (FMAs) and deciduous timber allocations. Harvesting is carried out in FMAs by Pelican at Rocky Mountain House and Weldwood at Slave Lake. Proctor and Gamble at Grande Prairie is testing aspen for pulp.

The other long term harvesting authority is a deciduous timber allocation. These are essentially the equivalent of coniferous quotas with controlled production volumes by four quadrants over a 20- year term. Aspen harvested under this type of disposition was first carried out by Dycks Containers in Lodgepole and Alberta Hardwoods in Slave Lake in the late 60s and early 70s. Now the major operator is Pelican in Edson and Whitecourt. In two years Millar Western Pulp will come on stream at Whitecourt.

There are three annual allowable cuts generated for aspen which identifies stands for harvest. These are:

1. Total aspen growing stock - all aspen is included from pure aspen stands, through mixedwood to coniferous with incidental aspen.

2. Deciduous bias - all pure aspen stands and mixedwood which are predominately aspen.

3. Pure aspen - only pure aspen stands and deciduous stands that have less than 30 m^3/ha of coniferous timber. This annual allowable cut (AAC) usually excludes A & B density[1] class deciduous stands which often contain spruce understories.

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[1] Density classification categories used in the Phase 3 Forest Inventory were based on 25% crown closure classes (A-D).

Aspen harvesting is authorized by licences and conducted according to the annual operating plan (AOP). This is when life becomes a nightmare for the foresters of both industry and AFS. Besides the complexity of how the hardwood AAC was developed, it becomes extremely complicated to program aspen cut blocks and coniferous cut blocks on one land base.

Presently harvesting is primarily directed to pure stands. In mixedwood stands the aspen is harvested by a selection process with the softwoods left for the next operator. This is not optimizing wood utilization. The first operator often has to waste the second operator's trees to get at his selected species.

Thus, for the Province to obtain good utilization of our timber resource, hardwoods and softwoods must be harvested in one integrated operation.

This private sector interface has generally not been accomplished yet. It appears blocked by company financial constraints and attitude. These must be overcome, hopefully by private industry initiative rather than government regulation.

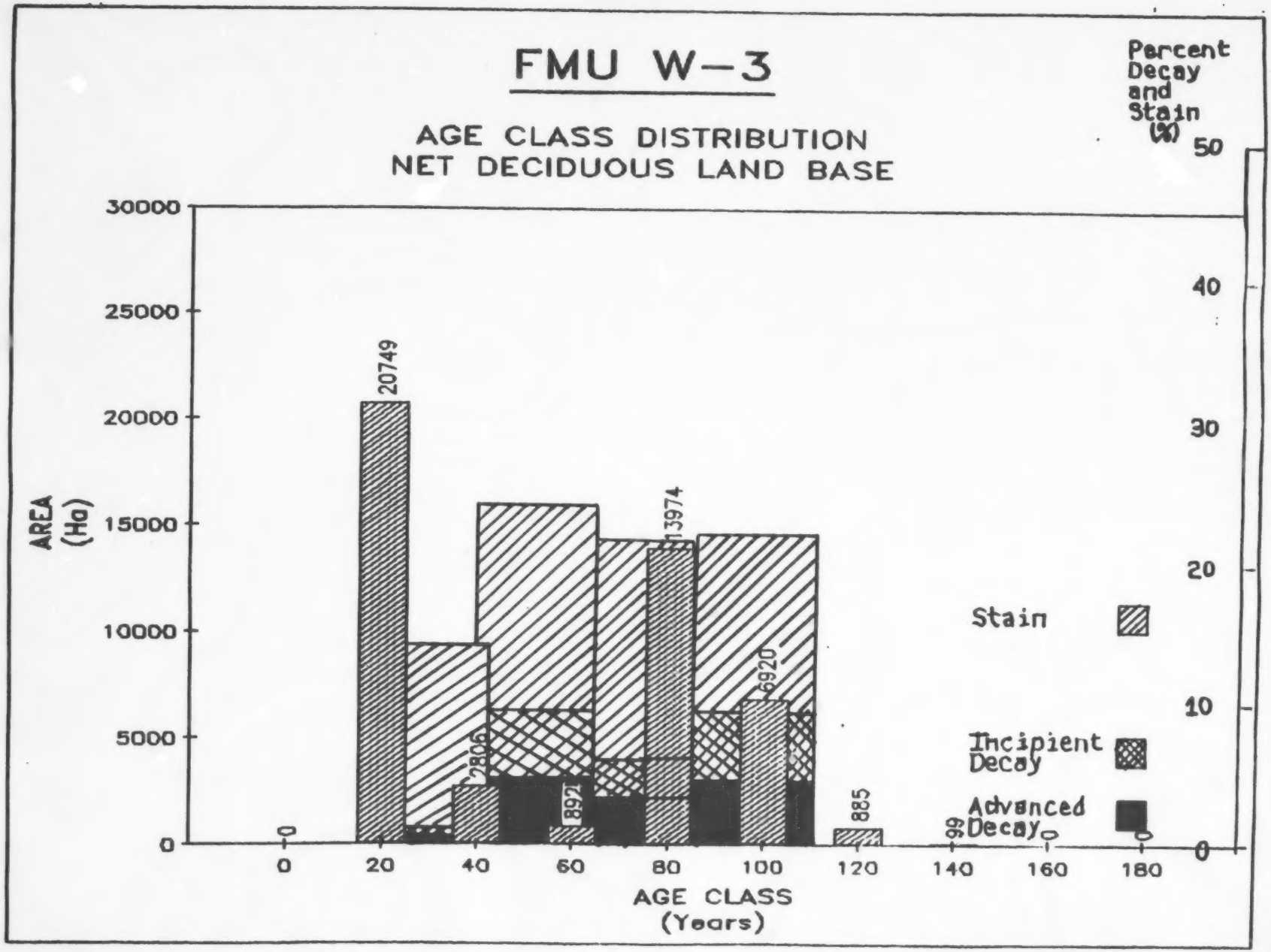
Both our softwoods and hardwoods are on the first cut cycle. We have to work with what Nature provided. There will be cull problems from harvesting the overmature aspen. However, technology must come forward so our hardwood resources can be utilized. I don't believe the Province can selectively harvest younger aspen and by-pass older aspen without developing a game plan. Perhaps some of the decadent over-mature hardwood stands can be silviculturally treated to start a new crop. Other alternatives are technology to permit wood recovery from higher cull trees by more effective logging practices. Example: field bucking and wood exchanges which direct a log to its best recoverable use.

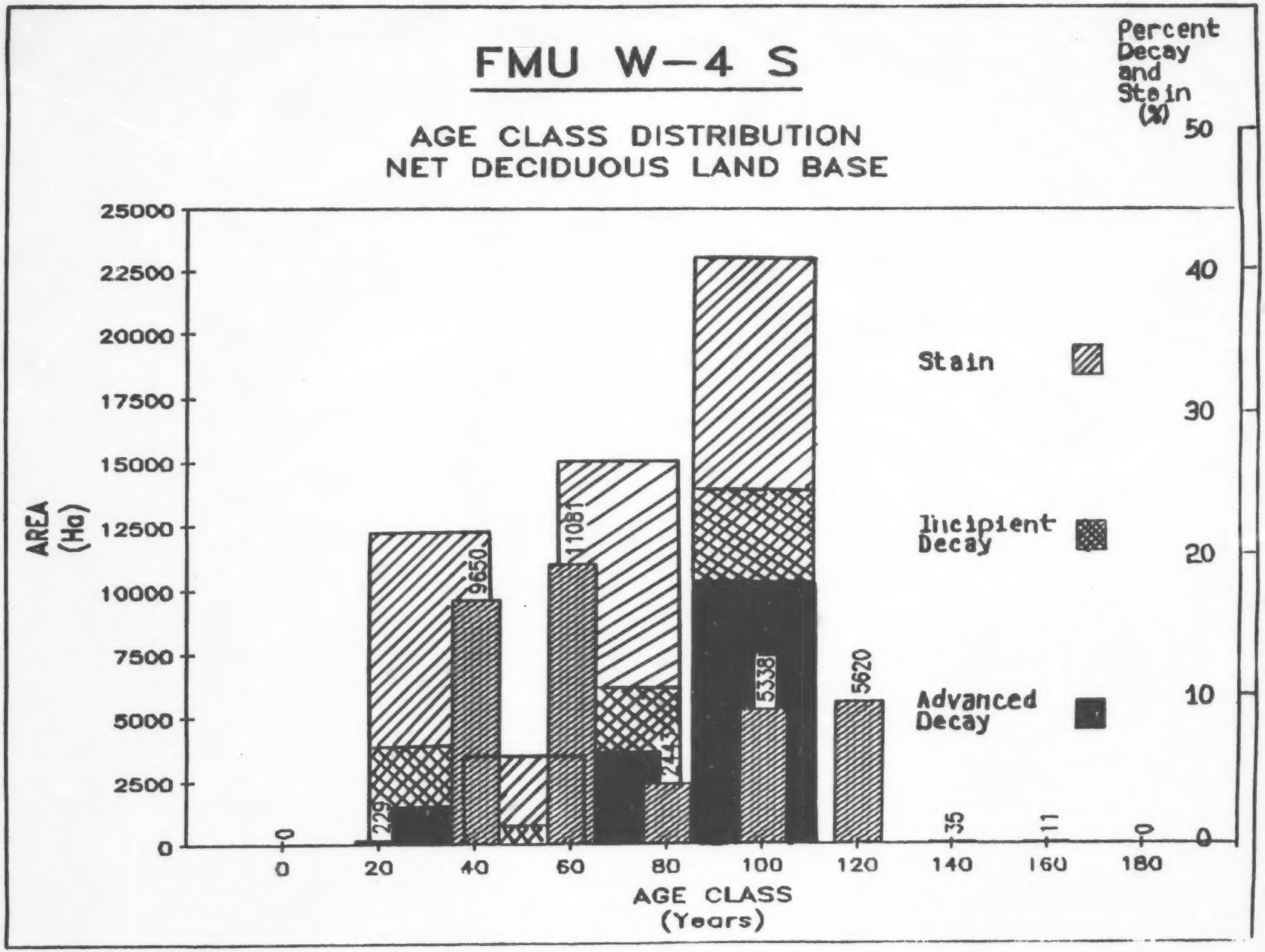
Cull in aspen in these older stands has been identified as a problem during this first cut cycle. However, I am not sure we can write these stands off. On a limited sample of our 80-year-old-plus trees, cull is averaging 5.3% advanced cull, 4.2% incipient decay, and 14.5% stain, as shown by the graphs generated for management units W3 and W4 (Appendix 1 and 2, pages 75 and 76).

Another concern when harvesting aspen is the protection of understory spruce regeneration often associated with mature aspen stands. Here our logging methods, equipment, and attitude are not adequately protecting the regeneration. Field managers are faced

with a very difficult situation. If we do not log the aspen now, recovery will be reduced when the understory spruce reaches harvest age, yet logging now severely damages the spruce. The forest management practice in the Whitecourt Forest is to restrict harvest in these types of stands to summer operations when understory conifers are more resilient to logging damage. Aspen logging is an important tool to release spruce understories, but to accomplish this goal, we need to rethink our logging methods. I hope the industrial speakers following me will be able to shed more light on the subject.

In closing I have some questions and comments to the Workshop. What has happened to technological advances concerning hardwood utilization? Twenty years ago black poplar and birch were harvested in Alberta. Today these species have no commercial use. Our present management is providing protection for these species in anticipation that technology will develop soon. Once again research must spur the development of these species so Alberta can make optimum use of our timber land base by a single harvest and reforestation sequence.


FMU W-3
AGE CLASS DISTRIBUTION
NET DECIDUOUS LAND BASE
Percent Decay and Stain (%)
AREA (Ha)
AGE CLASS (Years)
Stain
Incipient Decay
Advanced Decay
0
20749
2806
892
13974
6920
885
99
0
0
0
0
0
20
40
60
80
100
120
140
160
180
5000
10000
15000
20000
25000
30000
10
30
40
50


FMU W-4 S
AGE CLASS DISTRIBUTION
NET DECIDUOUS LAND BASE
Percent Decay and Stain (%)
AREA (Ha)
AGE CLASS (Years)
Stain
Incipient Decay
Advanced Decay
25000
22500
20000
17500
15000
12500
10000
7500
5000
2500
0
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
229
9650
11081
5338
5620
35
11
0

SIGNIFICANCE OF ASPEN CULL IN ORIENTED STRAND BOARD PLANTS

By
Mr. Norm Denney
Woodlands Manager
Pelican Spruce Mills
Edson/Drayton Valley

ABSTRACT

Relative to utilizing aspen for clear lumber production the oriented strand board (OSB) process is quite tolerant to aspen rot. In the harvesting process, cull is of greater significance because logging and hauling is paid for on a firm-wood basis.

Priorities in better aspen management are better species/-height/density stratification, better age class information, assessment of factors contributing to stand deterioration, and better methods of predicting stand breakup.

Generally the oriented strand board (OSB) process is quite tolerant to collar rot. What I'm going to say may sound a bit contradictory to what Norm Anderson just said, but I think I'm speaking in terms relative to utilization of aspen for the production of clear lumber or for the production of pulp.

We currently utilize logs that contain up to 50 percent incipient or advanced decay. Stained wood does not affect the process except for the appearance of the board. The incipient or advanced decay cannot be used in the board and as Mr. Anderson indicated, if it does get into the board, it creates undesirable board properties. Most of it becomes part of the wood waste which we use as fuel to dry the strands.

For those of you who haven't seen our plant, I'd like to briefly explain what happens to the cull in our process. The 8-foot logs come out of the saw ponds and are debarked and are cut into 33-inch lengths. The blocks are fed into the flakers which slice off strands 3 inches long, approximately 0.020 inches thick, and the desirable width is 1/2 inch to 5/8 inches.

The strands are cut tangentially from the longitudinal face of the log so that you get the grain of the wood running the length of the strand. When the flaker reaches the center of a log that contains rot, the knife has a tendency to break or crumble the unsound wood into fine particles and slivers. This material, along with the good strands, is transported to the dryers.

In the dryer drum, the temperature is set to dry the 1/2 inch by 3 inch by 0.020 inch thick strands and is very near the flash point of the wood. When the smaller slivers of rot hit the dryer heat, many of them ignite and burn.

After the strands are dried, they are passed through a series of screens which remove most of the remaining smaller pieces of unsound wood. In addition to the rot, the screenings contain other mismanufactured strands and bits of bark. This material is run through a hammer mill and used as fuel for the dryers. The decayed wood contributes very little to the heat value of this fuel.

In general, the aspen cull is not a major problem in the process. The throughput of the debarkers or flakers could be a problem if cull becomes excessive, and I think it's probably a little difficult to put a figure on what it would be to become excessive. As a general observation, I would say that if rot

became over about 20 percent, we'd have a problem in the green end of the plant.

On the harvest end, the cull is of much greater significance, and I think Mr. Anderson spoke to this quite well. The logging and hauling is paid for on a firm-wood basis. Cull percentage in aspen can easily jump 15 percent from area to area. If this happens, the logger has to fall, skid, limb, top, and buck 15 percent more trees in order to earn the same amount of money, or another way to put it, if a logger hits an area of high cull, his rate goes down 15 percent. A drop in earnings of this magnitude for many businesses would be enough to put them right out of business.

The transport of the cull is also a major factor. Log load size is restricted to a maximum weight as compared to many products that are restricted by volume. When the weight per unit of sound volume increases, hauling costs are directly affected. Because large-scale capital-intensive hardwood facilities will have to draw wood from relatively long distances, the percentage of cull transported will be critical. To partially alleviate this problem our hauling is done in short wood lengths.

Alberta [Forest Service] estimates we could harvest approximately 12 million cubic meters of aspen per year. The potential is great, but we have a lot of work to do in forest management before development will occur.

The first and most striking information gap is the stratification of the hardwoods on the maps, and I think we've talked about that already this morning, but I'd like to get a plug in for it also.

Having worked with the softwood maps for many years, I can look at a map designation and have a fairly realistic mental picture of what that stand looks like on the ground. With hardwoods, this is not the case. The black poplar, the birch, and the aspen need to be differentiated. Very little black poplar is currently being utilized, so in order to manage the aspen, we have to know where the black poplar is.

We need to either break the existing stratification into smaller units or come up with some other measures of the variability within the map designations that we have now. New

schemes to enhance the existing maps or to develop new ones in conjunction with the requirements of this particular industry, and the resource which supports them, are needed.

The next large information gap is the age of the hardwood resource. Accurate age data on the resource is a prerequisite to any kind of management. Without it, we can't develop realistic annual allowable cuts or harvest schedules. We recently completed an age survey where the maps indicated ages up to 140 years. We were able to find very few stands that were up to 120 years. The collection of accurate age data should be one of the first priorities.

A method other than cutting the tree down, cutting a disk off and hauling that disk home and planing it off and counting the rings would be much more economical. I don't know if it's possible to come up with methods that would make this easier, but it certainly would be worth looking at.

Related to the age problem is the prediction of stand breakup. At the current time, we are unable to say with any confidence how long the stand will last before harvesting either becomes uneconomical or the stand simply disappears. From a forest management point of view, this is probably the biggest unknown that we have. There are several factors involved in this occurrence. The prediction of the amount of cull is obviously the most obvious, but there may be other factors that could have an equally dramatic effect on how long the stand will survive. What are the effects of three or four years defoliation caused by tent caterpillar? Are there climatic and genetic factors to consider? Does an early or late snowfall cause the entrance of a lot of additional pathogens? I would suggest that perhaps some of these occurrences should be evaluated in terms of the probability of them happening during the life span of the stand.

This may be something like the study of heart disease. Doing a study on the number of people who die from heart attacks doesn't really tell you much, but to measure the effects of various factors like smoking and stress, or maybe stress from worrying about aspen decay, will tell you a little more complete story.

No matter what the cause, there's a fairly narrow time frame between the age of maturity and when the stand breaks up. Any potential development area with a large amount of growing stock that is around the same age, and many of the areas in this province I think have a large volumes of wood that are mature now, is going to have difficulty trying to achieve sustained yield management.

In summary, if we are to do a better job of the management of our hardwoods and maximize their potential, I feel the research priorities are: to first develop better methods of stratification to distinguish species, height, and density; the second would be better age information and more economical methods of collecting the information; the third would be assessment of the factors that contribute to the deterioration of the stand; and the fourth and last would be better methods of predicting stand deterioration and breakup.

ASPEN SOLID WOOD PRODUCTS

By
Mr. Horst Ramananskis
Manager
Sunchild Forest Products

ABSTRACT

Currently, Sunchild Forest Products produces pallets out of poplar and has a close radius market.

Marketing aspen for furniture lumber has special problems due mainly to varying levels of cull. In addition, no major secondary industry is in place to handle furniture grade lumber. An opportunity does exist in producing furniture dimension stock from aspen despite the special considerations required.

Sunchild Forest Products is an operating division of Pelican Spruce Mills. This is a rather interesting subject because pallets are manufactured out of poplar, to the extent we do, only in Alberta. Ontario and Quebec do not consider poplar usable wood for pallet production. Some is done in the States and pallets are manufactured out of poplar in Europe.

Our pallets have a marketing radius or shipping radius of 300 miles, so that means our market is rather limited. We are using approximately 7 million board feet of poplar. A few years ago everybody would have told you black poplar can't be used for producing pallets. That was a myth. Once it's dry, poplar is actually stronger than the aspen pallet, and therefore we are starting to utilize more and more black poplar.

There is no cost difference to us except that black poplar has some problems with ring shake which can be rather tough on the equipment, but other than that it nails and performs very well. Our product is shipped by our customers throughout the world. We have one company who is using approximately 200 pallets a day, and they're shipping throughout the world. In a way, that sounds rather promising for the pallet industry in using a lot of poplar, but it's not quite so because the national pallet pools refuse to use poplar. You have to use better quality poplar in pallet production.

As far as the utilization of aspen within our organization is concerned, we have done extensive research. When you see some of the pallets made out of white aspen, they look rather intriguing. The first thing that comes to your mind is why don't we just extract this beautiful lumber? The problem is that white aspen is not readily available. The percentage is extremely small, and I wouldn't attempt or advise anyone to just concentrate on extracting aspen and marketing it. You're certainly bound to fail.

If you are familiar with the hardwood grading rules, aspen can be marketed with stain and tight knots. This is an area we have started looking into.

To explore the manufacturing of aspen as furniture lumber is a very interesting area, but speaking only for our organization, I see it as a rather complex problem. First of all, we have no major secondary industry. We don't use this furniture grade lumber in large volume. If you go to the United States, Europe, Ontario or Quebec, you see operations that use millions and millions of feet

of lumber. We have a few smaller operators who use rather high-grade hardwoods, but not necessarily the low grades.

I have learned if you attempt to cut our aspen into furniture grade lumber, you will end up with a tremendous amount of No. 2 common and No. 3 common and very little clear and select material. These grades are defined by the National Hardwood Lumber Association rules.

To produce furniture grade lumber out of aspen and market it in this area wouldn't be very profitable because hardly any furniture can be produced from No. 2 - Common and No. 3 - Common grades.

Also what worked against the utilization of aspen for furniture production was that it couldn't be dried. The Alberta industry tried to dry aspen with conditions normally used with softwoods. Now we know that aspen has to be treated as a hardwood then you're able to dry it in certain kilns with special drying schedules.

Considering the problem of how to extract aspen furniture grade lumber out of our forests, I'm rather reluctant to believe that someone could go to Forestry and ask for some good stands of aspen to cut furniture grade lumber. That would be rather difficult situation to deal with because first of all, what happens if some of the trees are not sawlogs, or if they are undersized logs? The only way I could see that being overcome is if somebody is in a position to select the logs or buy selected logs from smaller operators. That would provide a possibility to extract logs which have a much higher recovery than if you would be forced to clear-cut an area.

Also, at this time in Alberta, we do not have sawmills that can saw the log to get the best grade. Random lengths and random widths must be cut to get the best utilization.

Some people do not recommend aspen for furniture production. Apparently the heart of the logs do not stand up too well as far as sanding and finishing is concerned. You can also encounter a great deal of collapse in the drying process.

An operation that would like to saw aspen would have to be fairly well integrated to have an outlet to operate and dry properly. They would also have to be able to do their own

marketing since nobody handles aspen in the Province. The demand for furniture dimension stock is not very well developed for aspen hardwoods to date.

However, an extremely interesting development has taken place over the last ten years in North America. Sawmills are able to sell dimension stock to the furniture manufacturer.

Historically, 20 or 30 years ago, large furniture plants had their own forests, sawmills, dry kilns, and their own lumber yards. In a modern furniture plant, the equipment is highly sophisticated and capital intensive. To remain economical they try to cut the size of stock required for their production. During the last ten years in North America, there has been concentration on sawmills specializing in producing furniture dimension stock, semi-finished and finished products.

For example, semi-finished stock would sell close to $2,000 per thousand boardfoot measure. Finished furniture dimension stock could go up as high as $3,000. If you take that into consideration, what you're shipping is only usable material. There's no waste. If you're able to extract aspen lumber out of Alberta's forests and you can approach that market, there's definitely a tremendous opportunity despite the capital outlay.

The furniture dimension stock would not have much of a market in Alberta or Western Canada, but certainly down East, California, and right across along the Pacific Rim there would be a market. Furniture dimension stock would include the processes of edge gluing, finger jointing, sanding, sizing, and being able to meet the furniture producers' demands to a very close tolerance and specifications. This is something very new for the Alberta secondary industry, but certainly, there is opportunity.

ASPEN MANAGEMENT - IMPROVED KNOWLEDGE FROM RESEARCH

By
Dr. Stan Navratil
Acting Director
Alberta Forest Service, Forest Research Branch

ABSTRACT

Overall, aspen research has been successful in Canada. Successful research areas include propagation, growth and yield, biomass estimates, thinning strategies, wood property studies, and cull studies. Cull defect volumes have been described for many provinces in Canada; however, work still needs to be done in the area of detection of rot and cull estimates.

Slide/Table 1

PROPAGATION/REPRODUCTION	
SHORT ROTATION TECHNOLOGY	(Stiell a. Berry 1986, Perala 1979)
GROWTH YIELD	(Bella 1970, 1972, 1975)
Yield tables, site indices	(Schlaegel 1981, 1975
Growth modelling	Edminster et al. 1985, Johnstone 1977)
BIOMASS ESTIMATES	(Pollard 1972; Bella and DeFranceschi 1980; Edwards, CFS, pers. comm.) (Perala 1979)
THINNING STRATEGIES	(Steneker, 1976, Perala 1977)
STAND DEVELOPMENT in relation to:	
Harvesting (type, intensity, timing)	(Bella 1986)
Initial suckering density	
WOOD PROPERTIES	

Ladies and gentlemen, I should clarify at the beginning of my talk that I will not be talking about forest product research but I will be talking about aspen management. That was my term of reference: to review contributions from research to improved knowledge and techniques for aspen management. Thus the title of my paper is: ASPEN MANAGEMENT - Improved Knowledge from Research.

I think we learned this morning very well that good management requires good understanding of the resource. And good understanding, in turn, requires and depends on good research and data.

In overall, I suggest that aspen research has been successful - or that it is a success story. There have been many contributions made and expanded knowledge provided to aspen management. I will review some of these points briefly and I will discuss cull aspects a little longer.

If we look at the list of areas where aspen research has been successful (Slide/Table 1)[1], we may start with propagation and reproduction biology of aspen.

Methods have been developed for aspen propagation including production of planting stock and plantation establishment.

If we reach the stage in aspen management that we would like to improve aspen quality by planting superior clones, the knowledge is available.

Short rotation technology has been developed. Studies comparing production at short rotations by the Canadian Forestry Service in Ontario and by the USDA Forest Service determined yields and the shortest sustainable rotation. The shortest rotation at which sucker production can be sustained is over 10 years. Armillaria infection in stump roots may contribute to declining yield and may prove to be a serious factor in any short rotation system for aspen.

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[1]Dr. Navratil's presentation was extensively illustrated with tables on slides. The material included in the slides is presented on the lefthand pages opposite the appropriate text.

Slide/Table 2

RECOGNITION/DELINEATION OF CLONES

- leaf flushing and discoloration
- leaf shape
- branching, natural pruning
- stem form
- bark pattern

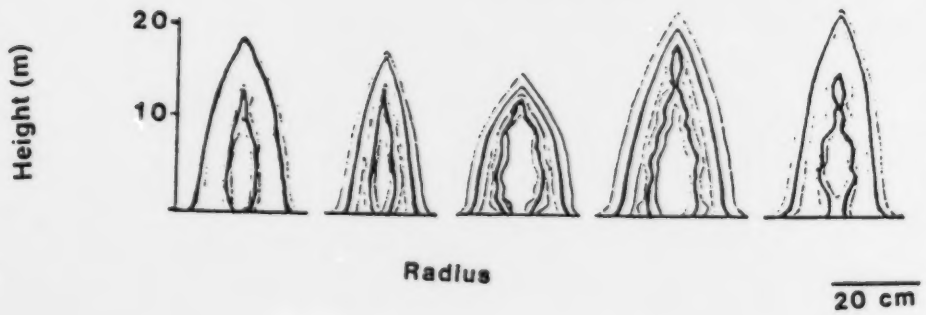
Slide/Table 3

CLONAL VARIATIONS in:

- suckering ability
- disease resistance, bioassays developed
- growth rate, biomass
- sensitivity to air pollution
- cull volumes (Wall 1971, Kemperman et al. 1978, Weingartner and Basham 1985)
- wood density, fibre length (Yanchuk et al. 1984 U of Alberta)

Slide/Figure 1

MANIGOTOGAN



(from Wall 1971)

Interest in wood as an energy source has stimulated studies in aspen biomass. As a result tables of biomass yields determined for aspen stands of various ages are now available in Alberta, Manitoba, Ontario, Minnesota and elsewhere.

Thinning strategies have been developed in terms of volume and sawlog production.

We have a very good data base and knowledge on stand development in relation to time of harvesting, intensity of harvesting, and as affected by initial suckering density.

A number of studies have been done in aspen wood properties.

Perhaps the greatest contribution from research has been in describing clonal variations and clonal nature of aspen. Not only that it was described but also the ways how to recognize and delineate clones in aspen stands have been defined. Some of these characteristics are listed in Slide/Table 2: leaf flushing, leaf shape, branching, stem form, bark pattern. Methods have been developed of how to use aerial photography for delineation of the clones. Through research, clonal differences in many traits important to aspen management have been defined (Slide/Table 3), like differences in suckering ability, differences in disease resistance, differences in growth rate, sensitivity to air pollution, and differences in wood density and fiber length.

Now, I guess the major contribution and what we will discuss at length are clonal differences in cull volumes. It is very rewarding to mention that it was a Canadian scientist, Dr. Wall, who first described clonal differences in aspen decay and volume of decay. It was followed up by our work in Ontario published in 1978 and expanded on by Weingartner and Basham in 1985.

In his original work, Dr. Wall had described clonal differences in decay and volume of decay, not only in terms of the incidence of Fomes igniarius rot but also in the patterns of rot columns within the stems. Slide/Figure 1 shows, for example, one of the diagrams of stem analyses from five different clones in Manitoba.

Slide/Table 4

DECAY FUNGI/TYPES OF DEFECTS

Fomes igniarius	(Basham 1958,
Radulum casearium	Thomas et al. 1960,
Peniophora polygonia	Hinds a. Wengert 1977,
Armillaria mellea, Pholiota sp.	Basham a. Navratil 1975)

Slide/Table 5

CULL/DEFECT VOLUMES

in Ontario	(Basham a. Morawski 1964
Alberta	Thomas et al. 1960,
	Hiratsuka a. Loman 1984
Minnesota, Rocky Mtns.	Schmitz a. Jackson 1927
	Hinds a. Wengert 1977)

Slide/Table 6

UTILIZATION OF DECAYED WOOD

Kraft pulping	(Hunt et al. 1978,
	Navratil, Lakehead U.,
	unpublished)
Chemical utilization	(Cyr and Schulz 1982)

We have an excellent knowledge base with respect to the micro-organisms associated with aspen defects or causing wood decay. The major decay fungi have been isolated and described (Slide/Table 4) and furthermore we know what types of micro-organisms, be it fungi or bacteria, are associated with different wood defects.

Canadian Forestry Service has provided over a number of years the leading role in these micological studies. And Dr. Basham who is today with us has been the prominent scientist in the field and I think we will all benefit from his presentation.

Through research and also through field studies, cull volumes and decay percentages have been determined for the main aspen regions in North America, including several cull studies in Alberta (Slide/Table 5).

It was mentioned several times today, and it should be emphasized, that there is considerable variability in cull and rot volumes between regions as well as between adjacent areas and stands.

Though the age-rot relationship is pronounced, there are obviously many other factors contributing to the development of defects and rot in standing trees.

Research also looked at the feasibility of utilizating decayed wood. For example, there have been kraft pulping studies done using decayed aspen wood (Slide/Table 6). Kraft pulping data showed 7 - 9% decrease in pulp yields for decayed wood as compared to sound wood. However, there was not a gradual increase in yield loss with greater proportion of rotted wood in chipped bolts. Pulp strengths from incipient-decayed wood and bolts with up to 15% of rot differed little from those of sound wood.

Here at the Alberta Research Council, chemical utilization studies have been done to determine the potential accessibility and utilization of carbohydrates in decayed aspen wood.

Now, I guess the central question and what was discussed vigorously this morning is to find out how can we predict and how can we manage and perhaps improve on cull and defect volumes in aspen stands. Let's review what we know and how research helped us and where information is inadequate.

Slide/Table 7

DETECTION OF ROT IN TREES
ESTIMATES OF CULL

External indicators - conks,
wounds,
branch stubs
Electronic methods (Shigometer)
Ultrasonic methods
X-ray

Slide/Table 8

INFECTION BY Fomes Igniarius

- avenues of infection?
- succession of organisms?
- size, age, height of branch stubs

(environment a. genotype)

We may start by discussing detection of rot in trees and estimates of cull. Many researchers and foresters have attempted to find a method to predict the incidence and extent of decay in standing trees (Slide/Table 7).

The presence of conks, followed by large scars and wounds, and large branch stubs indicate significant amounts of advanced decay. Though some of these methods may have regional application, in overall no reliable quantitative prediction of the amount of advanced decay can be made from examining external indicators. This is not surprising considering the many factors that control infection and decay development processes.

Several electronic methods have been tried with variable success. We tested the Shigometer, an electrical resistance meter for detection of wood defects. It can detect stain, wetwood and decay in standing trees and cut logs; in our sample in aspen stands the Shigometer was capable of detecting advanced F. igniarius rot with a 70% probability. The reason why the Shigometer has not gained wider use may relate to its disadvantages:

- it detects at the point of measurement
- measurement includes drilling a hole and this is relatively slow
- it does not work when wood is frozen.

Use of ultrasound, x-ray and imaging technology will be discussed in the following papers.

The potential gain from manipulating aspen stands to reduce decay losses will largely depend on our knowledge of the factors affecting colonization of aspen stems by Fomes igniarius. Most important is to consider Fomes igniarius patterns of infection and what affects the development of its rot (Slide/Table 8). There appears to be no simple answers. As you can see, I have many question marks on my slide. For example, there are questions about how Fomes igniarius enters the trees, what is the succession of organisms in the progress of decay development, and how size, age, and height of branch stubs affect infection and rot development.

Slide/Table 9

WHAT AFFECTS DEVELOPMENT OF F. igniarius ROT

- extent of heartwood (inner) wood
- residential microflora, bacteria?
- nitrogen content of wood?
- chemical composition of wood?
- antagonistic fungi?

We know quite a bit about Fomes igniarius in terms of the biology of fruiting bodies, pores, and where spores are formed inside of the pores. We know those spores are relatively resistant to environmental stresses, abundant, airborne, and can be disseminated over large distances. That's why removal of decayed trees from a stand can hardly change infection rates and cannot be recommended as a sanitary measure.

If you asked me a question about ten years ago how Fomes igniarius enters the trees, my answer would have been, it enters through branch stubs because it is a typical heart-rotting fungus. That's what was generally accepted. However, this concept has been challenged by several scientists. Fomes igniarius probably enters the tree anywhere where there is exposed wood, be it sapwood wounds or branch stubs or any exposed wood on the stems.

We know that the infection takes place only above ground. We have done some work with Dr. Basham and found that no F. igniarius infection seems to occur via parent roots, from parent stumps of the trees with Fomes igniarius rot into sucker stems.

We mentioned branch stubs as infection avenues. Some branch stubs heal very fast, others, those with relatively large bases, may heal very slowly thus providing infection points for longer periods. Branch stub healing and natural pruning are influenced by environment, stand structure and also genetic variation of clones, again, complicates the picture.

When Fomes igniarius is inside of the tree, many questions still remain; how long does it take before rot develops; how fast the decay will spread (Slide/Table 9).

Wood, in standing trees, believe it or not, contains a number of bacteria at a relatively high concentration. Though bacteria do not directly play a major role in wood decay they can affect the rate of colonization by decay fungi. Some bacteria form a close mutualistic association with decay fungi and provide decay fungi with vitamins and nitrogen. The amount of N in the wood has been linked to its susceptibility to decay. Hence, the differences in the bacterial population possessing N-fixing activity in trees could have a marked effect on their susceptibility to decay.

Slide/Table 10

EPIDEMIOLOGY OF F. igniarius ROT

- mechanisms of clonal resistance?
- environment/site influences?

It was not surprising that in a study in aspen stands in Northern Ontario we found considerable differences in bacteria concentrations between defect-susceptible and defect-resistant clones of aspen. Thus the question remains open.

Nitrogen content of wood affects susceptibility to decay. What about other elements, chemical substances and chemical composition of wood? We don't know.

An interesting concept has been advanced suggesting that perhaps we could use the fungi antagonistic to Fomes igniarius in biological control of Fomes igniarius decay.

In our study conducted jointly with Dr. Basham, we found that in young stands of aspen, Peniophora polygonia was the primary invader of stems present at a very high frequency. The fungus forms fruiting bodies on branch stubs. We formulated a hypothesis: since P. polygonia is the primary invader, is there any possibility that this fungus could provide control or some kind of protection against Fomes igniarius.

Through laboratory assays we indeed found that strains and isolates of P. polygonia were very active against Fomes igniarius. They totally inhibited the growth of Fomes igniarius mycelium in culture.

If we advance this finding further we can suggest that the differences in Fomes igniarius rot could be related to the variability in P. polygonia colonizing infection sites. In other words, in practical application of this finding, we shouldn't select superior stands and clones at ages younger than 20 - 30 years because at that time Peniophora polygonia forms most of the stain or incipient rot and the selection could be misleading in relation to stand resistance to Fomes igniarius.

The prospects of biological control should consider the manipulation of microecology to the advantage of these antagonistic fungi through natural pruning and healing of branch stubs.

Many more questions remain to which we have yet no answers. For example, what are the mechanisms governing clonal resistances? (Slide/table 10).

Slide/Table 11

STRATEGIES FOR GROWING
LOW DEFECT/HIGH QUALITY ASPEN STANDS

Effects of silviculture treatments

Herbicides	(Basham 1982b)
Scarification	(Basham 1982a)
Thinning - sanitary a. density control	
- removal of low-quality clones	

Identification of "high-quality" sites

Clonal management?

Treatments of overmature, decadent stands

We know that the clones differ in volumes and patterns of decay and that the genetic influences account for clonal variation in decay. Clonal studies from Ontario suggest that the genetic constitution of the clones contributes to variation in defects and F. igniarius rot, but on the average it accounts for less than one-third of the variation.

It has been shown that environment and site factors do play a very important role in these interactions; however, we don't know exactly what those environmental and site factors affecting decay development are. Thus at this stage we cannot utilize them to our benefit and incorporate them in the strategies of aspen management.

Priority should be given to developing techniques for growing low-defect, high-quality aspen stands. Can we form, at this stage of our knowledge, any of these strategies (Slide/Table 11)?

We need to assess the effects of silviculture treatments on the internal quality of aspen. Some ground work has been done. Dr. Basham (1982b) found that herbicide application and top killing of aspen suckers did not increase stem defectiveness.

Scarification and various types and timing of site preparation methods may need to be carefully evaluated. Barrel scarification of young suckers increased occurrence of wounds and internal defects (Basham 1982a).

Thinning may assume a significant role in improving stand quality through stand density control, sanitary thinning to remove decay-prone trees and through manipulation of clonal composition. In stands where clones are intermingled we could remove through thinning the low-quality clones.

In terms of overall clonal management, I'm not so enthusiastic. It appears that the concept of clonal manipulation has been a little oversold. Firstly, the genetic influence accounts only for about 30 percent of decay variation. Secondly, clonal management in stands where clones are well separated is very unlikely. Yearly gains in expansion of promoted clones are too small to make it operational. It may require 5-6 rotations before significant distribution of superior clones could be achieved.

Site classification and identification of high-quality sites may be the area where significant improvements could be achieved. Several studies indicated the importance of environmental and site variables in aspen defectiveness though these factors were in the majority poorly defined or crudely estimated. Perhaps a sensitive site classification system such as the Biogeoclimatic site classification that incorporates moisture/nutrient grids and climatic variables could provide the needed level of resolution.

The question of treatments of overmature, decadent stands has been mentioned this morning, and certainly we do have to, through research, design ways how to restore those decadent stands. Trials with treatment alternatives for restoration of decadent aspen and high-graded mixedwood stands, e.g. by shearing or prescribed burning, should be initiated and gradually evaluated. The extent of decadent stands requiring the conversion/restoration will increase.

In my conclusing remarks, I would like to go back to the year of 1972 when at the aspen symposium in Duluth. Dr. Keays predicted, and I quote, "At some time between now and the year 2000, probably between 1980 and 1990, the world demand for fiber production combined with the unavailability of softwoods will lead to the exploitation of the Canadian aspen resource". I think we have reached that stage.

Ladies and gentlemen, our mission is to improve the quality of the aspen resource. We learned today that it is by no means a simple task.

Aspen management will require more skill, finesse, and knowledge than we have used in the past. Increased utilization of aspen in Alberta will have a profound effect on forest management practices and strategies. We must design improved methods to produce low-defect, high-yield aspen stands and develop silvicultural systems for mixedwood stands.

It is true that, in many areas, research has supplied us with significant advancements. In overall, aspen research has been a success story. It is also true, however, that in many areas we cannot move fast enough because of the lack of knowledge. We may learn from these examples the value and importance of research continuity and the value of sound investment in research.

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ASSESSMENT AND PREDICTION OF STEM DECAY IN ASPEN STANDS

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ABSTRACT

Age is a much more reliable indication of the extent of stem decay in aspen than diameter, growth rate, or site. Aspen clones appear to have more influence on the amount of decay than site, but in both Manitoba and Ontario "superior" clones were rare, the faster growing clones generally having the most stem decay. Phellinus tremulae causes about 70% of stem decay in aspen, and because it frequently occurs above and seldom below 8 feet, non-destructive decay detecting devices and methods are of little practical use. Stem scars, cankers, forks, broken or dead tops, and rotten knots are usually associated with some stem decay, but the most reliable indicator is the presence of P. tremulae conks on the stem.

Because there is considerable variation in stem decay among trees in a single age class, large numbers of trees in each age class must be felled and dissected to obtain reliable estimates of the extent of stem decay. Discolored (stained) firmwood generally occupies 2 to 3 times the volume of decay in a stem. Some past decay studies of aspen appear to have not separated them, resulting in highly inflated estimates of stem decay. For research to be of the most use in forest management and utilization decisions, the incidence of stain, incipient decay, and advanced decay must be recorded separately.

First of all, I must make it very clear that I am not bringing any quick, easy solution to the problems facing you in Alberta concerning aspen decay in mature and overmature stands. Anyone who works on aspen decay quickly realizes how complex it is and how difficult it is to predict.

Also, I must point out that all of my work has been in Ontario. I'm not very familiar with the biology of aspen or the biology of decay pathogens of aspen in Alberta. My remarks will therefore be based on my own research on aspen decay in Ontario, plus much of the literature from Alberta and other provinces, and from the northern part of the United States.

Several fungi are involved in stem decay of living aspen, but only two cause roughly 90% of the volume of serious, advanced decay in mature and overmature trees. These two fungi are not known to occur in aspen younger than 20 years, but as aspen get older the wood becomes more susceptible and the points of entry for these fungi more common. Thus it is not surprising that in all aspen decay studies I am aware of, where numerous trees in several age classes were examined, age is the feature of individual trees or stands most closely related to the extent of stem decay. Within an even-aged stand or single age class, there is considerable variability in decay incidence between individual trees. This explains why the age-decay relationship becomes evident only when a sufficiently large number of trees and age classes are sampled. Of course, eventually as stands become noticeably overmature slight reductions in the extend of decay may occur because of the death or windthrow of the most decadent trees. Yasu Hiratsuka in 1984 published a report showing distinct regional variations in age-decay relationships in aspen. None of the studies he included were carried out in the Lake States of Michigan, Wisconsin and Minnesota where aspen matures much earlier and develops stem decay much faster than in the northwestern U.S.A. or northern Ontario. Nevertheless, in all regions a consistent positive relationship between age and decay incidence is evident in that report.

What other trees or stand features besides age can be used to estimate stem decay in aspen? Unfortunately, except for external signs on individual trees, nothing else has stood the test of time as being very reliable. For many coniferous species there are quite strong relationships between site and stem decay. However, in aspen there is much conflicting evidence concerning the effect of site on decay, both positive and negative correlations having been reported. Most reports show less stem decay on the better quality sites, but even these reveal the relationship as fairly weak. The clonal growth habit of aspen complicates the picture. Ron Wall working in Manitoba concluded the aspen clones differ in

their site preferences so that clones have a greater effect on decay incidence than site. In both his work and our work with aspen clones in Ontario, where the same clone occurred on two or more sites, differences in the extent of decay on different sites were not significant.

A faster rate of tree growth, indicating higher tree vigour, should mean a higher resistance to stem decay fungi. In species other than aspen this is usually, but not always, the case. Different clones in even-aged aspen stands show pronounced interclonal differences in growth rate of dominant and co-dominant trees. Thus both Wall in Manitoba and we in Ontario expected that the relatively fast growing clones would have the least stem decay. Unfortunately, this was not the case. Most of the fast growing clones in Ontario were the most defective; of 60 clones we examined, only two could be classed as "superior" when both growth rate and stem decay incidence were considered. In Manitoba, Wall also found that a fast growth rate and a low incidence of decay were not typically combined. Clearly in even-aged aspen stands there is not a good relationship between growth rate or tree diameter and stem decay because of clonal influences.

Several instrumentation and chemical methods for detecting internal tree decay show considerable promise. However, in forest stands of aspen they are of limited practical value because of the common occurrence of extensive columns of advanced decay that are out of reach, above 7 or 8 feet. These methods are useful in detecting decay in logs or products, but not in standing aspen. No doubt in the future they will be modified and improved so that they can provide estimates of all stem decay in stands, but to my knowledge that time is certainly not yet close at hand.

Attempts have been made to relate aspen bark color to stem decay. In 1968 a report out of Russia indicated that the "green-barked" form had less stem decay than the "dark-barked" form. Dr. Suezone Chow found the least defect in "white-green" bark trees compared with "green" and "grey-green" bark trees; however, these differences were not significant. Color estimates are largely subjective, and bark color is certainly dependent on clones and probably on age. All things considered, bark color does not hold much promise as a reliable decay indicator.

I am aware of two studies in which attempts were made to relate stem decay incidence with the occurrence of rotten knots in aspen. In two locations in Ontario, Alemdag and Honer found no relationship, whereas in Alberta, Bailey and Dobie found quite a good relationship.

Stem scars, cankers, forked stems, and broken or dead tops have generally been reported as quite reliable external indicators that some stem decay is present in aspen. However, in most stands only a small percentage of the trees possess any of these signs, and many trees without such signs have extensive stem decay. In all aspen decay studies there is agreement that the presence of fruiting bodies or conks of F. igniarius on the stem are by far the most reliable indicator of stem decay. F. igniarius causes 60 to 70% of the volume of stem decay in mature and overmature aspen. It has been shown that F. igniarius decay exists throughout the conk-bearing portion of the stem, but usually only a few feet above and below that zone so that conk-bearing trees can contain considerable lengths of sound, useable wood. The close correlation between the presence of F. igniarius conks and the extent of F. igniarius decay within individual trees has led to the development in the Lake States of a formula for predicting the extent of F. igniarius decay in aspen stands. However, it should be remembered that Radulum casearium, which accounts for roughly 20% of stem decay in aspen, and other decay-causing fungi do not normally form fruiting bodies on living trees so that their stem decays as a rule remain undetectable.

In our studies of aspen clones in six Ontario stands, correlations between external clone features and internal defectiveness were for the most part nonsignificant. The only consistent significant differences were found in branch diameter, degree of natural pruning and the occurrence of stem stain. The extent of stem decay, mostly caused by F. igniarius, showed significant interclonal differences in some stands but not in others.

One area where we need more knowledge is when, where, and under what circumstances, aspen are infected by F. igniarius. Conks are usually formed at or near branch scars, but not until several years after infection. Research on F. igniarius infection sites has yielded conflicting conclusions, based to a large extent on negative results. Often, if the fungus was not isolated from or would not infect dead branches, it was assumed trunk wounds are the usual point of entry, and vice versa. Iverson, at the University of Wisconsin, was unable to get F. igniarius spores to germinate either on trunk wounds or on dead branches. We have not done any direct research on this problem in Ontario. However, in our clonal study in a young 34-year-old stand smallish zones of characteristic F. igniarius decay were present in 21 of the 160 trees we examined. We carefully dissected each of these recently developed young decay zones, and without exception they appeared to have originated at branch scars. In fact, no stem wound could be detected in association with any of the decays. Furthermore, in our study of the effects of scarification wounds on the quality of young aspen,

stem wounds were responsible for appreciable stem decay. However, F. igniarius was never isolated from any of those decays, leading us to conclude that the major entry point is branch scars, not stem wounds. In our clonal study we found that the clones with the most efficient natural pruning generally had the most stem decay. Perhaps naturally pruned branches leaving very slightly protruding, or no, stubs are the preferred entry point, neither dead branches nor stem wounds! In view of the importance of F. igniarius in the management and utilization of aspen, more research is needed on this point as it could lead to silvicultural or other means of reducing its impact.

In assessing the extent of aspen stem decay in a region of a province, because of possible regional differences, there seems to be as yet no substitute for felling and dissecting numerous trees in all of the major age classes. Within individual intact trees the occurrence of decay is often hidden and is usually irregular and discontinuous from ground level to stem top in no predictable pattern. Thus it is wise to cut stems in lengths no longer than 8 feet or 2 metres, preferably less. Most trees older than 50 or 60 years will probably have some decay at ground level. These decays are caused by several fungi that enter primarily via the root systems and seldom extend more than 2 or 3 feet above the ground. The region around breast height is sometimes the least defective, because the trunk decays caused mostly by F. igniarius and R. casearium often occur above 6 feet or so.

I and most forest pathologists define decay as discolored wood that can easily be detected as softer than sound wood. It is caused by fungi that can penetrate and metabolize the cell walls, to the point where in its advanced stage the wood has lost all structural strength. Between this and healthy wood there are several stages of decay. The first reaction of sound aspen heartwood to invasion by these or other non-decay fungi is a faint discoloration which gradually darkens. For a while, sometimes even as long as 2 or 3 years, this remains just as hard and firm as sound wood, and can be utilized with few or no drawbacks in most manufacturing processes. For this reason I feel it should be described as stain, not as decay. As the fungus continues its attack on the cell walls the wood gradually softens, sometimes taking several years in one location before the advanced stage of decay is reached. Slightly softened wood is usually called incipient decay.

The picture is made more complex by the fact that some stains in aspen are not caused by fungi. Any wounds that result in exposure of the xylem to the atmosphere result in brownish discolorations which are of a physiological-biochemical nature, can

spread quite extensively, and contain no or very few microorganisms. Branch stubs can cause this type of stain, from where under certain circumstances it can extend into the stem as a form of darkened heartwood. Their only drawback is that they may increase the manufacturing cost for color-sensitive products. Another stain called wetwood can also occur in aspen. This may appear as an irregular zone around decay columns or the pith. It usually has a high bacterial count and moisture content. Bacteria do not cause decay and the stain is usually so faint that it generally disappears within a day or two of exposure to the air. Other stains are caused by fungi that have little or no effect on the cell walls, and cannot cause decay. All of these types of stain will not develop into decay unless they are subsequently invaded by decay-causing fungi.

Unfortunately I know of past instances where forest pathologists have used the term decay for any wood that was not clear, healthy sound wood. This can create very incorrect impressions in aspen, where the volume of stain can be 3, 4 or even 5 times the volume of decay. Anyone looking at Table 2 of Yasu Hiratsuka and Gus Loman's recent review paper on poplar decay is struck by how much higher Paul and Etheridge's percent decay figures are for aspen in the Lesser Slave Lake region of Alberta,. than those for the other seven studies. At age 71-80 they report 42% of volume decayed, whereas the average for the other seven studies at that age is only 9.1%, with a maximum of 14.5%. True, decay may well have been that extensive in the trees Paul and Etheridge sampled. However, the fact that their lengthy 1958 report does not mention the words stain or discoloration make me suspect that at least part of their high figure might be explained by stain having been included with decay.

In my opinion it is very important in studying stem decay in aspen to distinguish between not only stain and decay, but also between incipient and advanced decay. For example in a study carried out with Ken Hunt of Forintek we found that advanced aspen decay resulted in very inferior pulp strength, whereas incipient decay had much less effect on strength properties. Sophisticated, objective devices that are practical for distinguishing between stain, incipient decay, and advanced decay in the field may exist, but I am not aware of them. I can only recommend what I have been using for years, the point of a sharp knife such as a Swiss Army knife. By prodding several times sound wood on the end of a log and comparing the resistance provided to that of defective wood, a person can quickly become proficient at delineating zones where the defective wood is just as firm and hard (stain), slightly softer (incipient decay), or much softer (advanced decay). In some cases we have added a fourth category, moderate decay, where the stage of decay is judged to be close to the border between incipient and

advanced decay, but that is optional. The method is certainly somewhat subjective, but with practice can be made to work. Hopefully devices will be available some day to make these decisions more objective. One of the most promising I've seen is Suezone Chow's penetrometer, in which the measurable depth to which a spring-triggered plunger penetrates sound or defective wood is related to wood density and therefore to stage of decay.

Decays that are present on one end of a log or section but not on the other should be traced by additional cuts to discover approximately where they begin and end, if accurate decay volumes per trees are to be obtained. This might be done for stains as well. In Ontario we use logarithmic tree measurement forms on which we mark the diameters of the stem and of stain and different stages of decay at the appropriate heights. When completed, points representing the same paramaters can be joined, and with a planimeter or other device the area on the form represented by each defect and by the stem as a whole can be determined. By multiplying these areas by suitable factors the volume represented by advanced decay, stain, etc. can be calculated in square feet or square decimetres or metres. The total merchantable stem volume can also be determined, and the percentage of that volume occupied by the various defects calculated. The location of conks and other stem abnormalities such as scars and rotten knots should be recorded on the form.

Each fungus in aspen causes a characteristic stain or decay, but many are so similar in appearance that the eye cannot distinguish between them. It is helpful to know the identity and properties of the fungi associated with each defect. However, considering how much is known about the microflora in aspen, and how time consuming and labor intensive it is to isolate and identify them, I personally don't feel that it is necessary. With few exceptions, there are no practical reasons why it is desirable to know the identity of the fungi. One exception involves the fungus Peniophora polygonia which is almost as common in aspen stems as F. igniarius. However it seldom, if ever, causes advanced decay. Since incipient decays are all similar in appearance, it helps to know roughly how much of it is occupied by P. polygonia and how much by advanced decay fungi such as F. igniarius or R. casearium. As far as butt rots are concerned, the only one whose identity is important to know is Armillaria mellea, since its presence in several trees in an area usually means much of the root system is badly decayed by this fungus, making the trees more subject to windthrow. In certain situations it may be helpful to know how much of the stain is only wetwood or physiological stain, indicated by the absence of microorganisms or the presence of bacteria only; how much is inhabited by fungi that cannot cause decay; and how much is actually the first stage of decay indicated

by the presence of decay-causing fungi. However, depending on how large a region and the number of trees it is planned to sample, this is one procedure that could be omitted in my opinion.

As far as sampling is concerned, as mentioned before, because of the great variability in decay incidence that can occur between trees, I would say at least 30 trees per age class on a single site in each stand or sub-region should be sampled. Sampling should include all age classes older than 40 years where adequate sized samples are available. In case a useful relationship between site and decay extent exists, all major aspen sites should be sampled. Based on his work with aspen clones in Manitoba, Wall suggested that long, narrow transects rather than square or rectangular plots would result in less chance of sampling single clones and therefore in less bias. Stand history should be determined, if possible, as this can have an effect on stem decay incidence. In Ontario we are finding that aspen stands originating after cutovers tend to have somewhat more decay and stain than natural stands of fire origin. This aspect could be investigated as well if old enough stands of cutover origin are in the sampling region.

DISCUSSIONS I - C. Dermott, Moderator

QUESTION: Mr. Jones, how "hard" is that formulae (1.9 times the basal area)?

MR. JONES: We're not 100 percent sure that it's accurate, however it's in the literature; it was done in the Lake States country so we're utilizing it until something else better comes along.

We sense that the projections in the future are too liberal, so we don't use that section of the formula. We took that one point out, and we're adopting it and saying it's accurate enough for us. It gives us an idea that something more is going on than conks, and rather than using that gut feeling we have a standard that all of us can use. Time will tell whether it's accurate are not.

QUESTION: Are the suckers coming up from the stands that you're liquidating because of overmaturity or high cull relatively sound, or are they already affected by the same disease that affected the mature stand?

MR. JONES: We haven't been at it long enough, but we suspect that they'll be sound because they're coming up from the root systems. Most of the shearing is done in the wintertime when the ground is frozen, and with a good sharp shear blade on good frozen ground, we're getting good severing. We're not damaging the root system a whole lot, and hopefully that will be sound.

MR. ANDERSON: Dr. Basham, you just mentioned near the end that in cutovers in Ontario there was more infection in the harvested stands than in the fire origin stands. I was wondering how old the cutovers were?

DR. BASHAM: The oldest we have are about 40 years old. So it's really too early. The differences aren't that pronounced. We can't really come out right now and say that aspen originating from cutover is going to be more defective than aspen originating from fire. It just appears as though there is a tendency for them to be somewhat more defective.

DR. LOMAN: I'm Gus Loman, and I'm a consultant with A. A. Loman and Associates Ltd. I would like to react to Norm Anderson's presentation. He showed great difficulties in age/decay relationships when you compare different survey groups. Also, he showed a histogram of age classes where you have tremendous gaps in age classes.

I think there are about three problems in doing decay surveys in aspen. One is that aspen is an intolerant fire species and therefore it reflects fire history. If you want to do an age/decay relationship study, you may have gaps in age classes, yet you find age/decay relationship tables. It means that people have gone far and wide to collect the decay data and put them in one table. If you go far and wide, you deal with different site qualities, different stand histories.

Another problem is that many people have difficulties in separating mineral stains from incipient decay and incipient decay from advanced decay, so it depends on their own gut feeling and experience on how they're going to combine these two to get the total volume data.

Another problem is that different survey groups use different criteria to determine or to select decay. Pedology Consultants, Dobie and Bailey of Western Forest Products Laboratory for instance, cut their aspen in 8-foot lengths then rejected every log that had more than 50 percent decay. They didn't measure it. They took the logs that had less than 50 percent decay and measured it. They also only took logs that had top diameter to 9 centimeters, so they came out with fairly optimistic decay picture. At various age classes they would have 7 to 8 percent decay, while Colin Etheridge who also did decay studies in Alberta,but measured everything, have decay 3 to 4 to times higher. It's a multiple problem, and it's very hard to prepare different decay studies.

MR. BRECK: The only thing I can see from that is you're identifying problems from the past. We've got to look for things for the future and look at it from the industry representatives view. You've identified problems in measuring in the past, but what we're trying to come up with new ways of measuring for the future.

DR. LOMAN: If you go to the literature, you find that at least one person has found that decay patterns and decay percentages are related to clones, which means this might be a genetic factor, and the importance may be to identify clones and it's a pity that when they did aerial photography and they used springtime and summer that they couldn't do their photography in the fall because in fall colouring you can separate clones to ground check to see what the decay picture is for each clone or for representative clones or for clones in stands that are close to your plants.

The other thing I think is you still have to let the marketplace be the driving factor as you said. Realize that your best bet would be to get small products, I would say toothpicks, matches, chopsticks, wood for small boxes and then look at a market that may not be the United States because they might not be willing to buy, but go to China [for example].

MR. GRABOWSKI: Tom Grabowski from Silvacom. I would like to respond to the comments that were just made by Dr. Loman and Mr. Breck since I was involved in that Pedology study with the field work in Alberta. Just to clear the record, all disks were brought into the lab regardless of how much decay was found in the log and they were all measured in the lab using an electronic planimeter and an arbitrary differentiation between advanced, incipient, and stain, which followed Mr. Morgan's definitions regarding the softness of the wood, which is arbitrary.

We did measure the amount of decay, and logs with 50 percent or more advanced plus incipient, the entire volume of that log was called cull, and it was included in the percentages. That's in terms of setting the record straight.

The other thing is that there's been a number of studies done regarding Fomes igniarius or Phellinus tremulae on clones. I would cite Wall 1969 who said that Fomes among intermingling clones on the same site varied from 12 to 64 percent and on another site the variation was between 21 percent and 92 percent.

If you've got that kind of variation between the same clones that are intermingled on the very same site, it's no wonder that a lot of these other things that we're trying to measure such as broad scale mapable attributes or even just general site characteristics would fail to pick up differences in stain, incipient, and advanced decay. There has been some work done on the clonal differences, and I think that's the biggest problem.

MR. RICHARDSON: Hugh Richardson from Millar Western. I've got a question for Mr. Breck.

Mr. Breck, can you expand on pulping and bleaching costs and their increase with an increase in stain and rot content.

MR. BRECK: That's a fairly complex one, and it's got to relate back to what the marketplace is and what it's willing to pay for. The pulping itself is mechanical, so there isn't any more energy involved to take the fibers apart as you have more rot. In fact if it's all rotten, there's no energy required to take it apart. It's quite a nice arrangement there.

But when you get into the bleaching, we're not talking about the type of chemicals that they're using at P & G which disolve all of this material. We're trying to just change the structure of the molecules, and it requires peroxide. If we're looking at say 30 percent or so of stain and incipient decay, it may require in the order of 1 percent additional peroxide. Now, 1 percentage of peroxide is in the order of $25. That may mean nothing if you can sell the product. Let's put another 30 percent of stain into the mill. The marketplace is structured for an 80 brightness pulp and at roughly $400 per ton as your price for 80 brightness, if you knocked down to 75 brightness, which is the next brightness category below that, what you've got is $25 less per ton. Your markup between the 75 and 80 is only $25. If you're incurring a 1 percent peroxide cost at $20 and you're trying to move in where your net increment is only $25 to go up into the highest brightness, there's very, very narrow margins to play around in.

In the grades you're talking about with aspen, you need to get 80 brightness to even get into the marketplace. So you find that very quickly if your amount of decay or stain coming in starts going up or your wood which would equate wood costs and manufacturing costs, it's not worth even using the aspen. You can wipe out the profits very, very quickly. That's a long-winded answer to what you asked, but they're narrow margins. The amount that it costs just to bleach can be equated to the whole margin you're getting for moving into a product.

MR. SMITH: Cliff Smith, Alberta Forest Service. This is a follow-up question for Mr. Breck.

In your presentation this morning, you talked along the same line in terms of what would be a good target to shoot for.

I think you said 1 to 2 percent, and I believe you were talking about advanced decay at that point, were you not?

MR. BRECK: Yes.

MR. SMITH: Have you got any kind of a guideline for the stain aspect?

MR. BRECK: Well, what we've tried to do is to look at the cross-section of the forest and stain, incipient decay and rot, and we have taken samples of the pulp and run the pulping studies which you're familiar with. We've lumped them together because to bleach the incipient decay and to bleach the stain is about the same cost.

What's happening in there, as far as we can differentiate within the accuracy of the types of studies we're doing, is about the same, so we lump them together. We know that the incipient decay doesn't have any deleterious effect on the strength property of the pulp because the lignin is what's being detected initially. Rot itself does, but we're hoping that most of the rot will come out in the chipping operation.

We're looking primarily at a cost associated with bleaching, and we'd lump those two together and we'd look at a figure around 20 percent. We know that through pilot studies we can get to an 80 brightness if we have 20 percent rot. If we start getting above that level, then we can't get to that threshold level of 80 brightness to get into the market place.

DR. CHOW: Dr. Seuzone Chow, Canadian Forest Products

Mr. Breck, have you compared bleaching ability of stained aspen and the softwood, for example spruce?

MR. BRECK: Yes, we have, and there are two fairly good studies that have been done on looking at 100 percent decay, 100 percent stain, 100 percent incipient and at sound wood, and there's a lot of data on softwoods. The bleaching ability [of aspen] is a little bit better than you can get with the softwoods. For example, you can take stained aspen and bleached it up to an 80 brightness, where quite often you can't take a sound softwood and get to 80 brightness.

DR. CHOW: The results are quite consistent with what we found in the laboratory. We did a lot of different bleaching methods, and we find that the aspen stain is very tough.

MR. BRECK: It can be bleached. If it couldn't be bleached, we wouldn't even be able to look at aspen.

DR. CHOW: You have to use more drastic measures for aspen stained wood than for softwoods.

MR. BRECK: Yes, but it's the cost that is critical. There are also many stains. What's the difference between mineral stains and stains associated with the bacteria that come in with the fungi or reactions that occurred there? Some may be bleachable, but some may not be.

I have a question for the audience. In other industries you look at changes in a property, especially density, by things like sonic attenuators. You pass the sound through it and see how this is attenuated. Can this be applied to the decay things we're looking at because the differentiation between incipient decay and advanced decay is really a density change in the wood, and densities are directly related to the ability to pass sound or some type of a wave through that.

Is there any research being done on that?

DR. SWANSON: I will talk about that this afternoon, but the answer is yes.

MR. DENNEY: I have a question for Mr. Westfield regarding their work in Minnesota on the different flushing times of the aspen. I was wondering if you have very much elevation variation in the States and whether this causes much of a problem with photography where you've got a hill that rises up to 1,000, 2,000 feet in an area?

MR. WESTFIELD: No, our topography isn't that drastic except for along the shore lines of Lake Superior. Ours probably varies 200 feet at the most across a slope. So I would say probably the most critical factor for causing certain amount of aspen to flush late would be its contact with a cold moist site

and then it may come out late. We have some clones that come out very early, but on the seven to ten days that I quoted, the majority of aspen is out. We wait until it's all out and we're still ahead of all the other species.

We do not have a whole lot of variation. It's more maybe genetics or age. In the fall photography that I showed, our aspen is 3, 4 inch diameter and 30 feet tall, it's already leafed off by the time we're photographing it. We can tell from the moisture grading what is hardwood.

We haven't had any complaints from anybody saying the aspen wasn't out yet when we took the photos. It seems to come out pretty consistently. Do you feel that it will vary quite a bit here?

MR. DENNEY: Well, I don't know, but I think the topography is such that on the west slopes we're going from the 2,000-foot level to the 3,500-foot level and it might be within one photograph or within one flight line. Then you break over a hill and you're on a north facing slope at 3,000 feet, and it can be quite a different climate out there.

MR. WESTFIELD: That is a factor we don't have to deal with and that's something that will have to be looked at here. I guess I was talking to somebody at coffee break and saying that basically the best thing to do is to get the plane and the camera ready and when the leaves are flushing fly every sunny day you have and then go back and start looking at it. That's basically what we're doing.

MR. ANDERSON: I don't know whether it was Mr. Westfield or Mr. Jones, but it was mentioned that in Minnesota, some of the operators want 70 percent sound wood and that the waferboard operators wanted better quality. Another problem mentioned was that of dryer fires in waferboard plants. What do you think is the average rot content going into the mills in Minnesota; not the maximum, but the average?

MR. WESTFIELD: I don't have any idea. I don't deal with that, so I don't know.

MR. DERMOTT: Mr. Jones, have you got any idea?

MR. JONES: No, I really don't. The 70 percent was a standard set by the U.S. Forest Service. That's the standard. That's not necessarily what the industry is accepting. I don't know what the average content is, but there's some pretty poor stuff going in the mill.

MR. ANDERSON: One of the problems we have here is standards say 50 percent and over cull you can reject, but 50 percent you have to take in. The problem with the aspen resource is when you get to a stand that is 50 percent, the whole stand is often close to 50 percent cull, whereas in coniferous species you might get 1 tree in a 1,000 that is at 50 percent. We get a steady diet of it.

CANFOR RESEARCH ON ASPEN WOOD QUALITY

By
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ABSTRACT

Canadian Forest Products Ltd. (CANFOR) has substantial interests in northern Alberta and British Columbia where there is an abundant aspen resource for future development. Starting in 1982, CANFOR Research initiated two large aspen research projects. One is "On-Site Wood Quality Determination" and the other is "Pilot Plant Research on Aspen Utilization".

Today, I have been invited to present our work on the on-site wood quality determination project. However, because the work is still in progress I will not be able to give you details of the results and conclusions.

Our research is being conducted on three fronts: chemical properties, wood quality and on site detection with instruments.

We selected five sites and each site was surveyed and photographed by helicopter in the early spring. A ground crew was dispatched to check the condition of the forest and soil characteristics and then cut down trees for sample study. Some of the logs were transported to a small sawmill for whole length sawing to observe the decay development along the trunk. A penetrometer was made to assist the differentiation of different degrees of decay. Density and fiber variation from the pith to the bark of aspen and spruce wood, grown side by side, were also examined with an x-ray densitometer and by the physico-chemical method. Decrease in density of the wood was found to have a significant relationship with advanced decay of the aspen wood but not with the stained wood.

X-ray flourescence electron microscope examination of the aspen wood containing different degrees of stain and decay found that calcium and potassium contents of the wood had a very significant relationship with the decay wood. The greater the element content the greater was the degree of decay found in the wood. The association of copper and zinc contents with decay of wood was not significant.

Electron-spin Resonance (ESR) spectrum showed a strong response in decay wood in comparison to that of sound wood. The half-life for the free radical decay was found also to differ greatly for the sound and decay wood. Further work on this subject is under way.

Four instrumentation studies were made using an ultrasonic detector, nuclear magnetic resonance scanner, penetrometer and stress wave equipment. We found that of the four instruments, the stress wave and penetrometer probably were the most practical and convenient at the present time. However, it should be noted that none of the instruments alone can provide reasonable determination of on-site quality; a trained technician with systematic knowledge of the instrumentation and the external and internal characteristics of aspen wood could be the best answer to the very difficult aspen problem.

SCANNING AND IMAGING TECHNIQUIES FOR ASSESSING DECAY AND WOOD QUALITY IN LOGS AND STANDING TREES

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and
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ABSTRACT

Commercial use of aspen and balsam poplar has had limited success due to widespread difficulty detecting internal defects. Internal scanning and imaging techniques for accessing decay and wood quality in logs and standing trees were evaluated. The ability to scan, identify, and locate wood defects would permit the use of improved computer optimized log and lumber breakdown.

The ability to detect decay and define wood quality characteristics non-destructively for logs and standing trees would be an important development to Alberta's forest industry. This capability would allow improved forest management and maximum product value extraction from the harvested resource. We and other researchers estimate the value of solid wood products would be increased by fifteen percent and the impact of silvicultural treatments could be immediately evaluated.

The full and efficient utilization of major species in Alberta requires minimizing the impact of defects on solid wood or reconstituted wood products. Commercial use of the major hardwood species, trembling aspen and balsam poplar, has met with limited success due to the widespread existence of difficult-to-detect internal defects including wet pockets, pocket rot, incipient decay, and stain. Better utilization of the major softwood species (lodgepole pine, alpine and balsam fir, and black and white spruce) would also result from a knowledge of the moisture distribution, chemical composition, and location and nature of defective or abnormal regions. The ability to scan, identify, and locate the position of these types of wood characteristics would permit the use of improved computer optimized log and lumber breakdown.

The objectives of the present study were to carry out a comprehensive literature review and conduct experiments to identify and evaluate potential opportunities for current internal scanning and imaging technologies for assessing decay and wood quality in logs and standing trees. X-ray-computed tomography and magnetic resonance imaging techniques were used to demonstrate the potential for scanning and imaging decay and wood quality in logs for several Alberta species. Potential productivity increases and savings for primary mills were estimated, and recommendations for further research and developments were to be made.

An extensive literature search provided knowledge about the current capabilities of microwaves, ultrasonics, X-ray and gamma-ray-computed tomography and magnetic resonance. The literature searches focussed on the past two years.

Short, fresh-cut log sections of several Alberta species were examined for the presence of decay. The log segments were then scanned using X-rays and magnetic resonance imaging and cut open to correlate the physical presence of these and other wood characteristics with the produced images. Benefit cost information was developed from the researcher's awareness of the current state of the technologies and through private communications. Research and development recommendations are based on implementation of these technologies.

Our studies have shown that current internal scanning and imaging technologies can assess decay and wood quality to varying degrees. Microwaves are limited to shallow penetration and do not differentiate defects easily. Ultrasonics can differentiate a wide range of wood characteristics but have major technical problems related to acoustic coupling, resolution, response speed and equipment configuration.

X-ray and gamma-ray-computed tomography (CT) provide useful two-dimensional, gross density maps related to specific gravity and moisture distribution. Through interpretation they can detect and differentiate decay, knots, cracks, worm holes, annual rings, insect cavities, pruned branches, sapwood/heartwood boundaries, bark and resin pockets, blue stain, rocks, moisture distribution and impregnation of liquor. CT scanners may be applied in sawmills within the next two to three years. Small portable scanners are under development. The main concerns are radiation hazards and analytical software requirements for interpretation.

Magnetic resonance (MR) imaging may be the most promising technique because it provides a two-dimensional image of the chemical environment in the material as well as proton (1H) distribution and has no associated radiation hazards. Each characteristic of interest creates a unique chemical environment resulting in a unique magnetic resonance signal. These signals can often be isolated, analysed and potentially imaged separately. Magnetic resonance also occurs for many nuclei besides protons. These magnetic resonance characteristics provide substantially more opportunities for development than are possible using X-ray or gamma-ray methods. MR spectroscopy provides information about the several distinct signals that can be detected, including the T1 and T2 relaxation times and permits correlation of these with the physical and chemical characteristics of wood. This information provides the knowledge required for optimizing images of these various characteristics. One of the relaxation times (T1) shows promise for species separation. The following defects and internal characteristics can be detected using magnetic resonance techniques: knots, sapwood/heartwood boundary, decay, moisture distribution and wet pockets, worm holes, shake, annual rings, juvenile wood, bark, resin pockets, blue stain, rocks, liquor or preservative impregnation and environmental pollutants. Emerging fast scanning and low magnetic field techniques may reduce scan times, improve resolution and reduce equipment costs. A current imaging equipment limitation revealed by our studies is the requirement for a moisture content greater than the fibre saturation point. New equipment developments coupled with the knowledge being generated from magnetic resonance spectroscopy will permit the detection and imaging of systems with very low or even no moisture content.

Our experimental studies have provided a preliminary evaluation of MR and CT techniques. The results confirmed and extended the claims made in the literature. They indicate what future work needs to be done to develop and commercialize these techniques. The commercial application of current scanning technology to image internal characteristics of logs and standing trees requires scanners that are less expensive and still have adequate resolution. The correlation between internal characteristics and scanning parameters must be more completely defined. Light, portable equipment will have to be developed for the field if these techniques are to be applied to standing trees.

The most promising internal scanning opportunity is the application of magnetic resonance techniques. Future research and development efforts should be continued in this area and expanded or initiated on several fronts. Spectroscopic studies should continue to define the correlations between MR parameters and internal characteristics. These studies will allow the specifications to be developed for advanced imaging equipment. Imaging with current and emerging fast scanning and low magnetic field equipment should continue and concentrate on developing interpretation software and analytical techniques, especially graphics. Finally, links need to be established with major equipment manufacturers to explore equipment development opportunities that focus on lower priced and portable systems, as well as incorporating the opportunities recently identified from spectroscopic studies.

REFERENCE

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WOOD QUALITY AND THE INCIDENCE OF DECAY IN BALSAM POPLAR IN ONTARIO[1]

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ABSTRACT

The generally low decay resistance of poplar wood is a serious problem adversely affecting both resource quality and utilization. Some estimates put the extent of decay in mature poplar stands in Canada between 25 and 30 percent. Decay-related degrade often renders the economics of poplar lumber, veneer and plywood production marginal.

This paper reports the results of a study on wood quality variation and the incidence of decay in balsam poplar in Ontario. Thirty-eight sample trees were cut from five locations along a North-South transect. Wood quality variation within trees followed patterns that are typical for poplars; i.e., fibre length, diameter and wall thickness increased from pith to bark. Average specific gravity for all sample trees was 0.325. Specific gravity within trees decreased from the fifth to about the tenth ring, after which it increased gradually to the cambium. Specific gravity showed a slight negative correlation with growth rate. The incidence of decay and heartwood discoloration was greater in trees from the south than in trees from the north.

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[1]Although it was listed on the Workshop agenda, this paper was not presented at the formal session because the principal author became seriously ill at the last moment.

It is a well known fact that presently still less than 10% of the allowable annual cut of 41 million cubic metres of poplar wood is harvested in Canada. Estimates of current levels of annual cut range from 2.5 to 3.6 million cubic metres. One of the major impediments to expanded utilization is the high incidence of decay, especially heart rot. Decay is quite common in mature trees of all native poplar species. Thomas (1968) reported a 25% incidence of decay in 70-year old aspen stands in Alberta on good sites. For balsam poplar the figure was about 12% at a stand maturity of 110 years. He emphasized that the overall condition of the poplar inventory becomes increasingly decadent because poplar species mature at a relatively early age. Apparently, site factors play a major role in the development of decay.

The high incidence of decay (i.e., poor resource quality) alters the economics of poplar utilization rather negatively. No product or industry can escape the negative effects. Decay reduces pulp yield and pulp strength, and it may add to bleaching costs. For waferboard, decay increases the proportion of fines (i.e., rejects) and thereby reduces product yield. Panel strength may also be decreased. The strongest negative impact of decay is found in the lumber, veneer and plywood industries. These industries are especially sensitive not only to "product yield" but also "value yield". Decay, of course, lowers both.

Unfortunately, the "decay problem" (i.e., "resource quality problem") that is inherently present in the existing mature (and overmature) stands is not going to disappear or diminish overnight. Like many other problems with forests and wood, it has to be or should be "managed". Management may involve several approaches. For example:

-- early harvest

-- shorter rotation

-- integrated utilization

-- new uses for low-grade wood

A long-term approach to the decay problem may also involve the application of genetics. It is quite remarkable that genetics and tree breeding research during the past few decades was able to produce disease-resistant poplar clones. Perhaps it is time that we suggested to the poplar breeders and pathologists that they should not stop at the leaf and the stem, but they should also consider the decay resistance of wood. Who knows, disease resistant poplar clones may also have more durable wood!

BALSAM POPLAR

The Tree

Balsam poplar (also known as balm poplar, balm-of-Gilead, balm, black poplar, rough-barked poplar, tacamahac) grows across Canada throughout the Boreal, Great Lakes - St. Lawrence, and Acadian forest regions (Hosie 1973, Maini 1968). It may grow in pure stands or often in mixture with willows, aspen, white birch, black spruce, white spruce, and balsam fir. It grown best along river banks on moist, rich soils.

Mature trees are usually in the range of 18-24 m. (60-80 ft.) in height and 30-60 cm. (12-24 in.) in diameter. On good soils, tree heights of 30 m. and diameters of 120 cm. are not uncommon.

Wood Anatomy

The Textbook of Wood Technology (Panshin and De Zeeuw 1980) describes the anatomy of balsam poplar together with cottonwoods (P. deltoides, P. heterophylla and P. trichocarpa). This approach has some justification since general anatomy of these species is quite similar. The difficulty arises when variability in anatomy and properties is at issue, as is the case in genetic selection and tree improvement. The sapwood of balsam poplar is nearly white, frequently merging into the heartwood gradually (Panshin and De Zeeuw 1980, Mullins and McKnight 1981); thus, the sapwood-heartwood boundary is not always well defined. Sapwood width appears to be quite variable from wide to narrow. Heartwood is usually greyish-brown to reddish-brown. The wood is generally odorless; but sometimes it has a disagreeable odor when moist.

Growth rings are discernible but are often inconspicuous, with considerable variation in width. Pores are barely visible to the naked eye. Pore arrangement is diffuse-porous to semi-diffuse porous. The semi-ring porous structure is more prevalent in fast-grown trees. Grain is usually straight and texture is regarded as medium-coarse.

Vessel-to-fibre-to-parenchyma tissue ratios have not been published for balsam poplar, but, for example, Panshin and De Zeeuw (1980) reported the following values for eastern cottonwood and bigtooth aspen:

Species	Percent of Total Wood Volume			
	Vessels	Fibers	Ray Par.	Axial Par.
P. deltoides	33.0	53.1	13.7	0.2
P. grandidentata	33.8	55.0	11.1	0.1

Generally, the number of vessels per unit area in the cross-section (hence, vessel volume) is quite variable. The "usual" range quoted for poplars is between 20 and 33 percent (Kennedy 1968). Although Isebrands (1972) found a range of 24.5 to 52.4 percent in the content of vessel tissue for two P. deltoides trees.

Fiber content is more important in paper making than is vessel content. While no specific data is available for fiber volume and its variation in balsam poplar, the figure of 52 percent quoted for P. deltoides may serve as a guideline. Again, Isebrands (1972) reported considerable variation in the fiber content of eastern cottonwood, ranging from 44 to 72 percent. Anderson and Zsuffa (1975) found fiber content of 52 to 65 percent for six hybrid poplar clones.

For average fiber length, Panshin and De Zeeuw (1980) quote the following values for three poplar species:

Species	Ave. Fiber Length (mm)	Std. Deviation (mm)
P. grandidentata	1.33	0.17
P. tremuloides	1.32	0.22
P. trichocarpa	1.38	0.19

These values are useful as a basis for comparison with balsam poplar.

Fiber length is an important wood quality parameter because it influences paper properties. For example, Horn (1978) reported that tearing strength of sheets made from hardwood pulps is principally dependent upon fiber length for both unbeaten or beaten fibers ($r = 0.817$ and 0.832, respectively). This contrasts with

paper made from softwood pulps in which cross-sectional area and wall thickness are the dominant variables. Burst and tensile strengths of hardwood pulps were influenced primarily by a combined effect of fiber length and cell wall thickness as measured by the pulp fiber flexibility ratio (length to thickness or L/T ratio).

Fiber length is also important in tree improvement work because evidence from the literature suggests that it is under moderately strong genetic control. For example, Farmer (1970) calculated broad-sense heritability values of 0.43 to 0.48 for fiber length in eastern cottonwood.

Properties and Utilization

The wood of balsam poplar is light in weight and is moderately soft. Published specific gravity values (green volume basis) range from 0.30 (Markwardt and Wilson 1935) to 0.372 (Kennedy 1965). The incidence of "wet wood" or "wet pockets" in freshly felled trees has been reported by Mullins and McKnight (1981) and Kennedy (1974). Moisture contents in wet pockets are considerably above those of the surrounding wood. Wet pockets are often associated with bacterial activity, usually occur as an irregular zone between sapwood and heartwood and are often characterized by darkened appearance. Wet pockets may complicate uniform drying and may become target areas for the development of collapse during kiln drying.

Presently, information about the incidence and frequency of wet pockets in balsam poplar is scanty, at best. Yet the authors are aware of a general "negative attitude" to the utilization of balsam poplar in industry. The most often cited reasons seem to be unusually high moisture content and related process problems.

Based on published strength properties, balsam poplar is slightly weaker than trembling aspen although they are included in the same species group together with largetooth aspen, red alder and white elm, and all may be commercially marketed as Northern Aspen.

Balsam poplar together with aspen and other poplar species is used for the manufacture of veneer, plywood, waferboard, particleboard, lumber, and pulp and paper products. The lumber, in turn, may be used for light frame construction, pallets, boxes, crates and furniture parts.

MATERIALS AND METHODS

During the summer of 1981, 38 sample trees were felled from five different locations in Ontario. The locations were close to a North-South transect of 80° West longitude, ranging from Moosonee in the North, to Cambridge in the South (Figure 1). A single disc (about 5 cm. thick) was removed from the trunk of each tree at breast height. The actual geographic locations were:

Moosonee	8 trees
Kirkland Lake	8 trees
North Bay	3 trees
Lake Simcoe	5 trees
Cambridge	14 trees
Total	38

At the time of sampling, the following parameters were determined and recorded:

- tree height
- diameter at breast height
- age
- length of clear bole
- stem form, taper and branching

In the laboratory, the following wood characteristics were determined:

- heartwood variation, discoloration, apparent biological deterioration, and their relation to age, diameter, and site region;
- sapwood/heartwood ratio;
- growth rate in diameter;
- variation in specific gravity, fiber length, fiber diameter and wall thickness with respect to age.

RESULTS AND DISCUSSION

Stem Characteristics

As expected, total tree height, clear bole height and stem diameter at breast height were all correlated with tree age. The regression lines were linear for all three parameters. There was considerable variation between trees of the same age group and geographic location. Clear bole height may be regarded as particularly important from the view of the wood-using industries, trees with the greatest clear bole being the most desirable. It would be useful to know whether clear bole height, stem form and branching characteristics are under some degree of genetic control. Similarly, what is the influence of spacing and environmental factors on clear bole height?

The pattern of bark thickness variation was quite interesting. Minimum bark thickness, which is essentially the thickness of the "live" inner bark, remained quite constant between young and old trees. Maximum bark thickness, or the thickness of the "dead" outer bark, increased linearly with age. There was considerable variation between trees of similar age groups and geographic location.

Sapwood-Heartwood Characteristics

Percent heartwood and sapwood/heartwood (SW/HW) ratio are correlated with tree age (Figures 2 and 3). Interestingly, trees in the south have a higher percentage of heartwood, at any given age, than trees from the north, indicating that environmental factors associated with geographic location may play a role in heartwood formation. However, there is considerable variation in heartwood percentage between trees of similar age group and geographic location. This evidence suggests that heartwood content, at least in part, is under genetic control and, therefore, may be used as a selection criteria.

Preference of the poplar-using industries is for light-coloured wood (i.e., sapwood). Since the SW/HW ratio in the majority of young trees (20-35 yr. old) is in favour of sapwood, a suitable rotation age should be selected accordingly.

Total extractive content of sapwood appeared to be independent of tree age, but there was considerable variation between trees of similar age group and geographic location (Figure 4). The extractive content of heartwood showed a positive correlation with

tree age. The presence of decay in several sample trees probably has a confounding influence on the results, although there were trees with some heartwood decay showing both low and high extractive content. It is difficult to compare our data with those of other workers, since published information on the wood chemistry of balsam poplar is scarce. Pearl et al. (1959) found the extractive content of balsam poplar wood to be 3.5 percent using 75 percent propanol as the solvent. The same solvent removed 4.12 percent extractives from trembling aspen. Clermont and Schwartz (1951) reported extractive content of 4.0 percent. From the view of wood processing and utilization, low extractive content may be regarded as the desirable trait.

The presence and extent of decay is one of the major impediments to a broader utilization of the native poplar resource. Thomas (1966) stated that the overall condition of the poplar inventory becomes increasingly decadent because poplar species mature at a relatively early age (e.g., 70 years for aspen and 110 years for balsam poplar). At that age, aspen is about 25 percent decayed and balsam poplar about 12 percent. Apparently, site factors play a major role in the development of decay. This contention is supported by some of the evidence from the present study. For example, the majority of trees with the heart rot were from the South (i.e., Cambridge) and none of the trees from the far north (i.e., Moosonee) showed any advanced decay.

Diameter Growth and Specific Gravity

Average diameter growth rate increased, to about 25-30 years of age, after which it decreased gradually. This is not surprisingly since at a younger age trees usually grow more vigorously.

The average specific gravity of all sample trees was 0.325. This is somewhat lower than the "species mean" in Canada (Kennedy 1965) but higher than the 0.31 "species mean" published in the U.S. (U.S.D.A. Wood Handbook 1974). It should be noted that the Canadian value was obtained from a relatively small sample size (ten trees from two locations in Ontario and Manitoba).

Average tree (i.e., disc) specific gravity was independent of age, but there was considerable variation between trees of the same age groups and geographic location. Since other investigations (e.g., Farmer 1970, Randall and Cooper 1973, and Einspahr et al. 1963) provided evidence to suggest that specific gravity is under some genetic control in poplars, specific gravity may also be used as selection criteria in balsam poplar.

From pith to bark, specific gravity decreased slightly from the 5th to the 10th ring, after which it increased gradually to the cambium (Figure 5).

The relationship between growth rate and specific gravity of poplar is intriguing and somewhat controversial. In the present study, a negative correlation was found between growth rate and specific gravity. Similar evidence was reported by Paul (1956), Cech et al. (1960), Kennedy and Smith (1959) and others for poplar. On the other hand, Johnson (1942), Boyce and Kaeiser (1964), and Farmer and Wilcox (1966) found no correlation between growth rate and specific gravity. Finally, Brown and Valentine (1963) reported both positive and negative correlations between specific gravity and growth rate in P. tremuloides clones. While faster growth rate may lead to somewhat lower specific gravity, this trend does not appear to be strong, and it would be more than offset by the increased rate of biomass production.

The anatomical parameters most closely associated with specific gravity variation are fiber ratio, wall thickness and diameter (Scaramuzzi and Ferrari, 1964).

Fiber Anatomy and Morphology

Three important fiber parameters were determined and analyzed: fiber length, diameter and wall thickness. Average fiber length for an entire disc (i.e., tree) showed only modest correlation with tree age. Overall average fiber length for the species was 1.00 mm. Within a disc, fiber length increased significantly from pith to cambium, with most of the increase occurring during the first 15 years (Figure 6). Similar patterns of increase has been reported for poplar species by several other investigators (for example: Kaeiser 1956, Boyce and Kaeiser 1961, and Anderson and Zsuffa 1975, Holt and Murphey 1978, Murphey et al. 1979).

Average fiber diameter and wall thickness of entire discs showed no correlations with tree age, but there was considerable variation between trees of the same age group and geographic location. The pattern of variation from pith to the cambium within a disc was different for these two parameters. Fiber diameter increased rapidly during the first 15 years and thereafter more gradually. Fiber wall thickness, on the other hand, showed a linear and gradual increase from pith to the cambium.

Both fiber diameter and wall thickness showed a "mildly" positive correlation with growth rate. This, again, may be

interpreted as a useful relationship since fast growing trees may be expected to produce fibers of superior quality.

Another aspect of the analyses concerned the relationships between fiber diameter/wall thickness and fiber length, and fiber length/diameter/wall thickness and specific gravity. A fairly strong positive correlation was found between fiber diameter/wall thickness and fiber length ($r = 0.76$ and 0.72, respectively). For tree improvement this means that when genetic selection will yield longer fibres, this will likely be accompanied by increases in fiber diameter and wall thickness, apparently positive developments. The relationships between fiber parameters and wood specific gravity were weak.

Conclusions

a) A positive linear correlation was found between tree height, clear bole height, diameter at breast height and age of tree. Considerable variation was evident between trees of the same age group and geographic location. Differences between geographic locations were not significant.

b) Minimum bark thickness at an average of 3.23 mm (i.e., thickness of inner bark) remained constant with tree age, but maximum bark thickness increased linearly with age.

c) The average proportion of bark (i.e., bark volume) of the total disc cross-section was 14.2 percent.

d) Sapwood-heartwood ratio decreased exponentially with increasing tree age. Lower ratios were found for trees from the south than from the north.

e) Heartwood percentage increased linearly with tree age, with trees from the south showing higher percentage of heartwood than trees from the north.

f) The incidence of decay and heartwood discoloration was greater in trees from the south than in trees from the north. The proportion of decayed and discolored wood increased linearly with tree age.

g) The rate of growth in diameter increased to about 25-30 years of age, after which it decreased gradually.

h) Average specific gravity for all sample trees was 0.325. From pith to bark, specific gravity decreased slightly from the 5th to the 10th ring, after which it increased gradually to the cambium.

i) Fiber length increased significantly from pith to cambium, with most of the increase occurring during the first 15 years.

j) Fiber diameter and wall thickness increased from pith to cambium. Diameter increased rapidly during the first 15 years and thereafter more gradually. Wall thickness showed a linear and gradual increase from pith to cambium.

k) A positive correlation was evident between fiber diameter/wall thickness and fiber length. For tree improvement this is an important and useful relationship since fiber length is under fairly strong genetic control.

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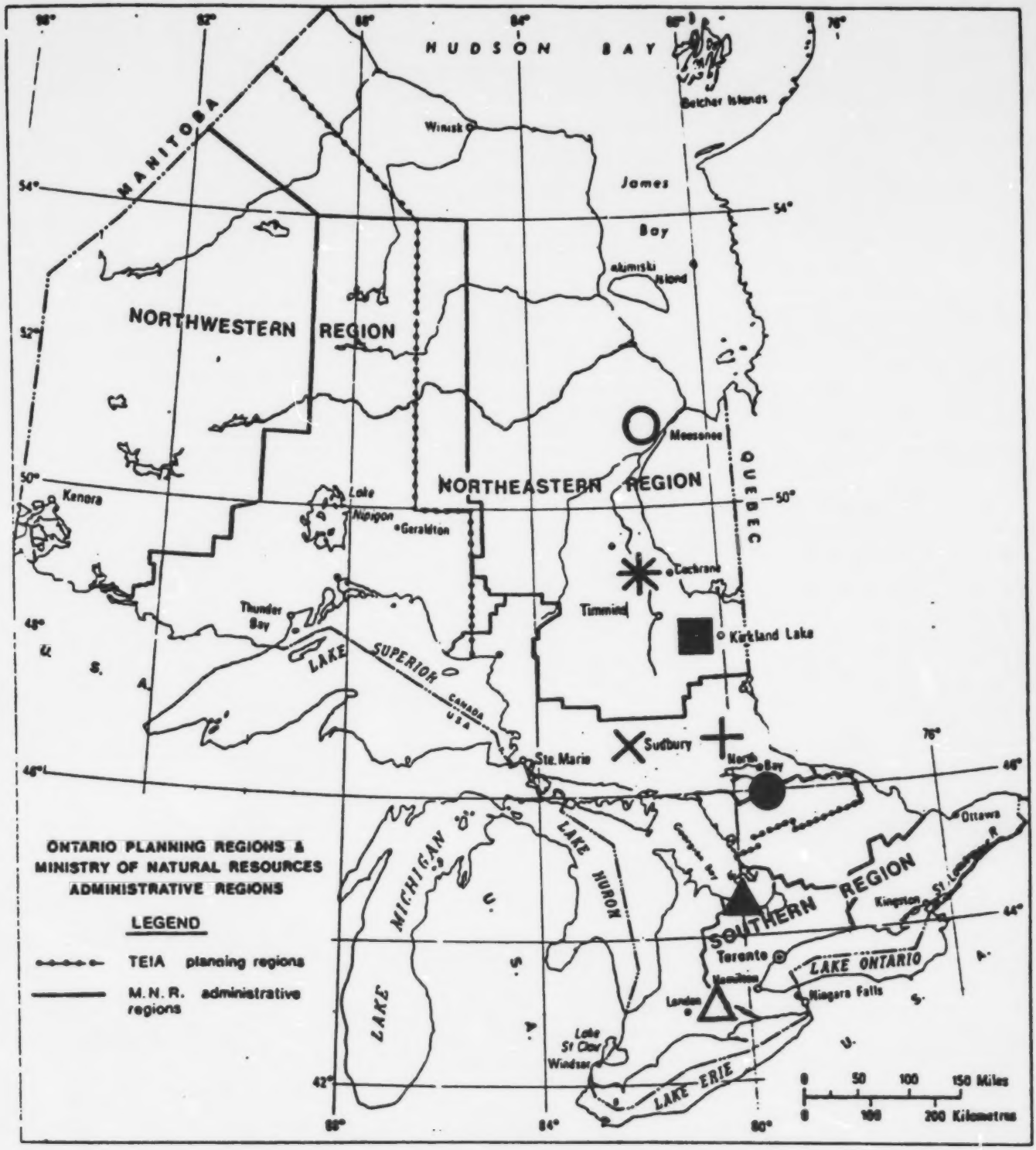


Figure 1. Location of sample trees.

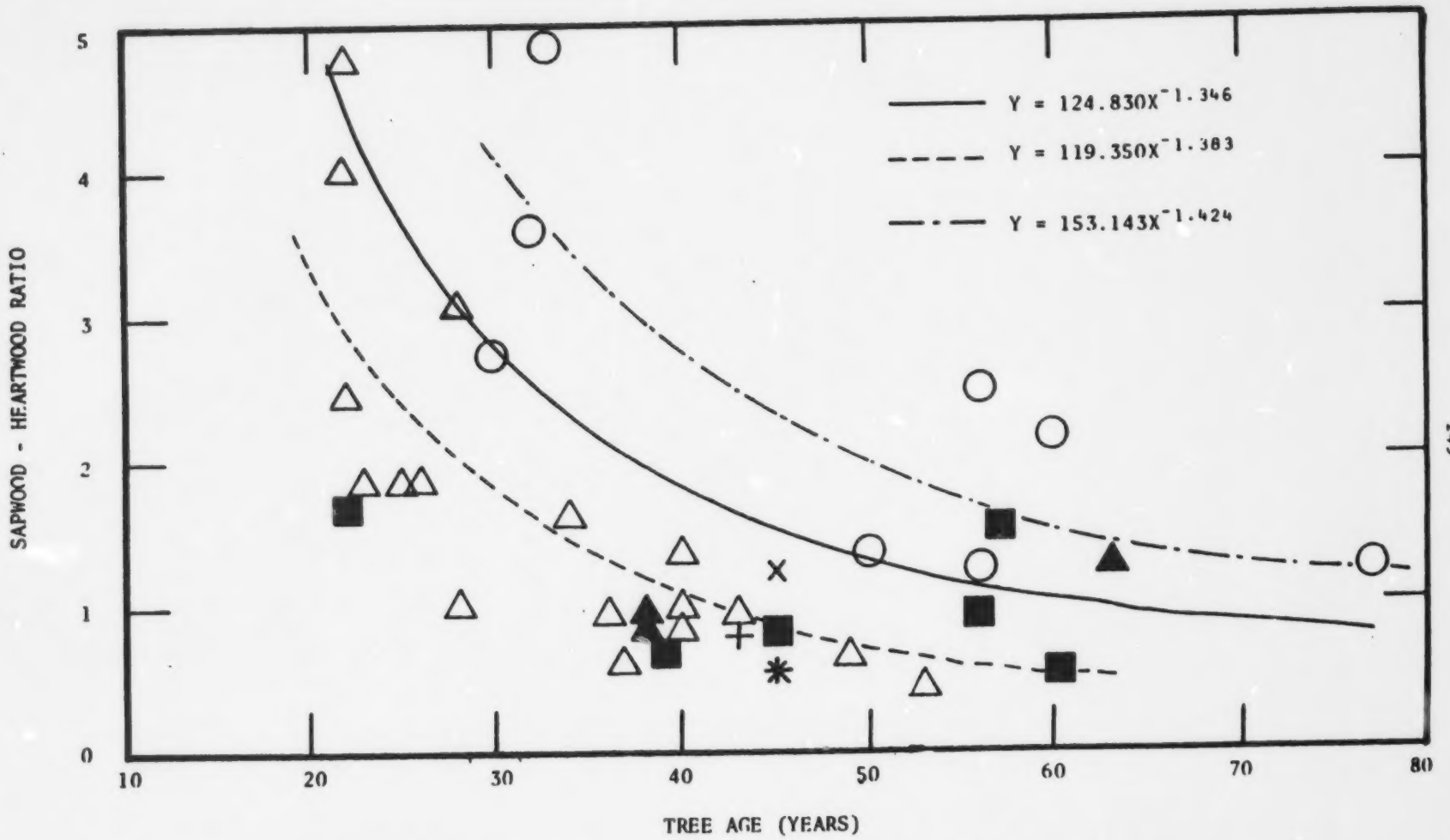


Figure 2. Relationship between Sapwood - Heartwood Ratio and age for 38 balsam poplar trees from different regions of Ontario.

———: Regression curve for total 38 trees. – – – –: For 14 trees from Cambridge District.
—·—·—: For 8 trees from Moosonee District.

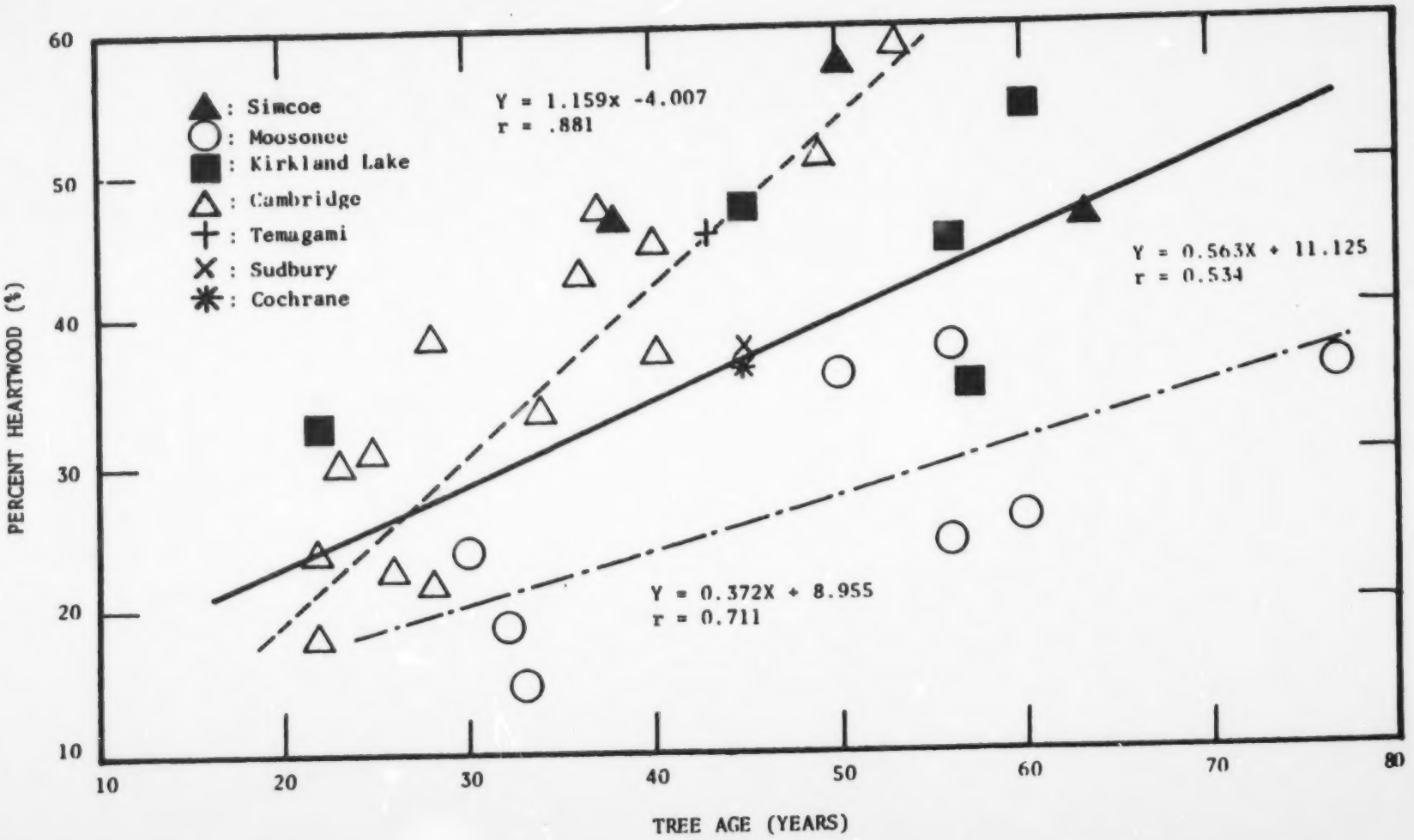


Figure 3. Relationship between percent heartwood and age for 38 balsam poplar trees from different regions of Ontario.

——— : Regression line for total 38 trees. – – – –: For 14 trees of Cambridge District.
—·— : For 8 trees of Moosonee District.

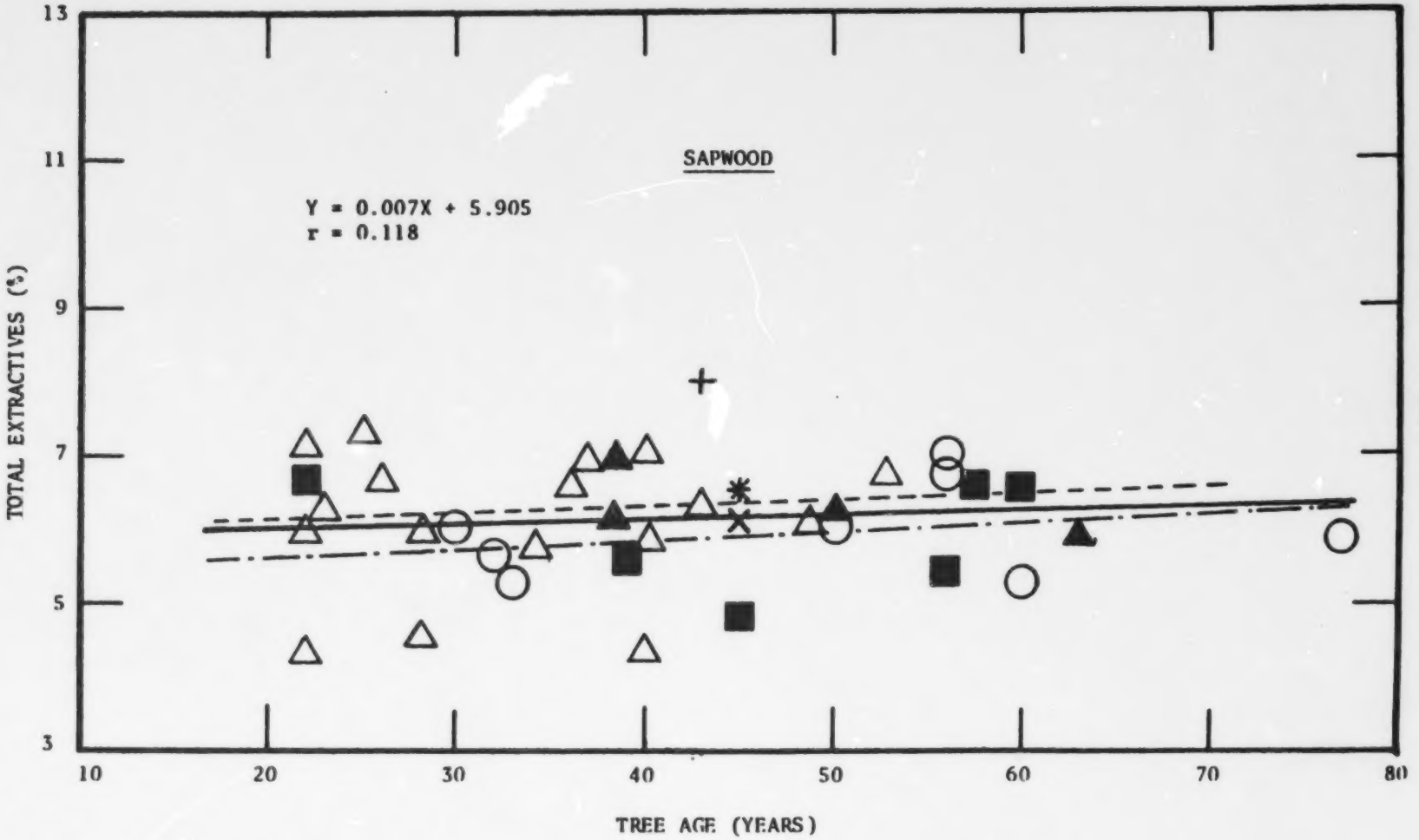


Figure 4. Total extractives of sapwood in relation to age for 38 balsam poplar trees.

———: Regression line for total of 38 trees. – – – –: For 14 Cambridge trees.
—·—: For 8 Moosonee trees.

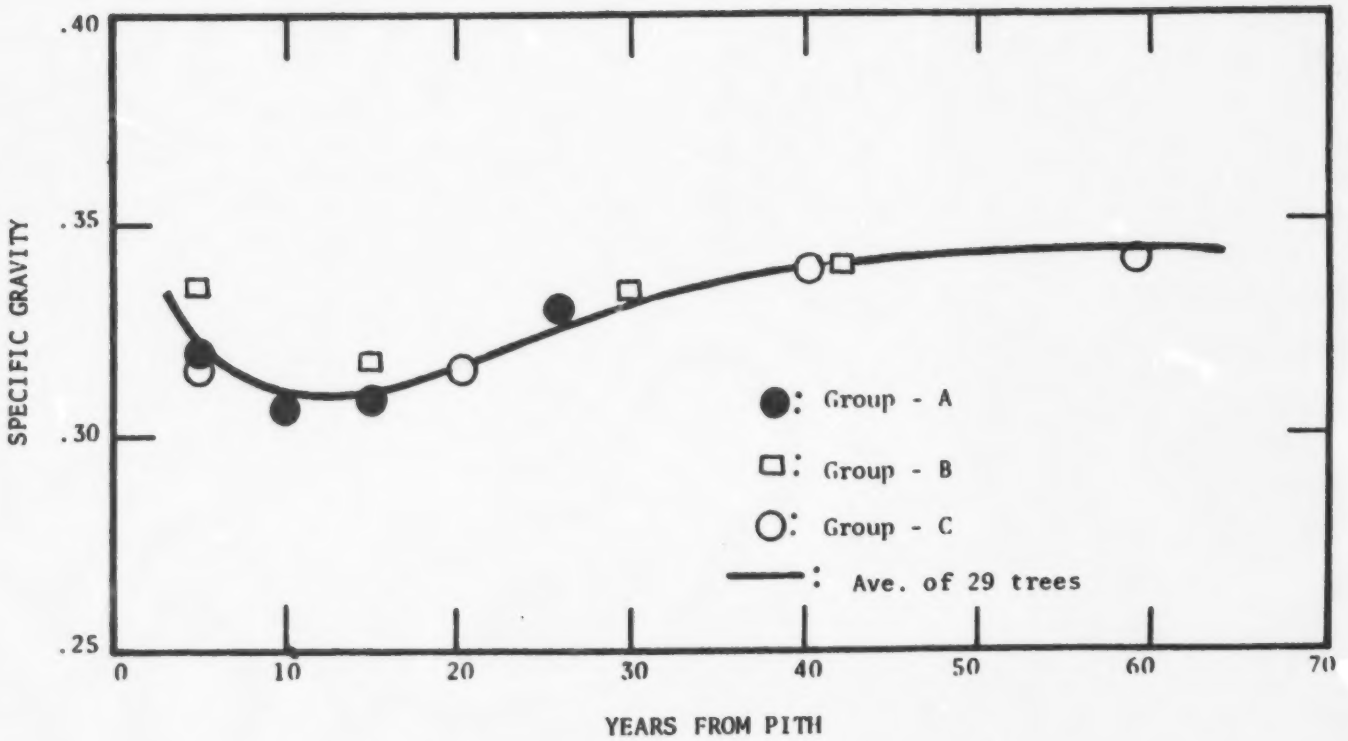


Figure 5. Relationship between specific gravity and years from pith for 29 balsam poplar trees of different age groups.

Group - A: Trees between 22-34 years (Ave. of 10 trees)
Group - B: Trees between 35-45 years (Ave. of 10 trees)
Group - C: Trees between 49-77 years (Ave. of 9 trees)

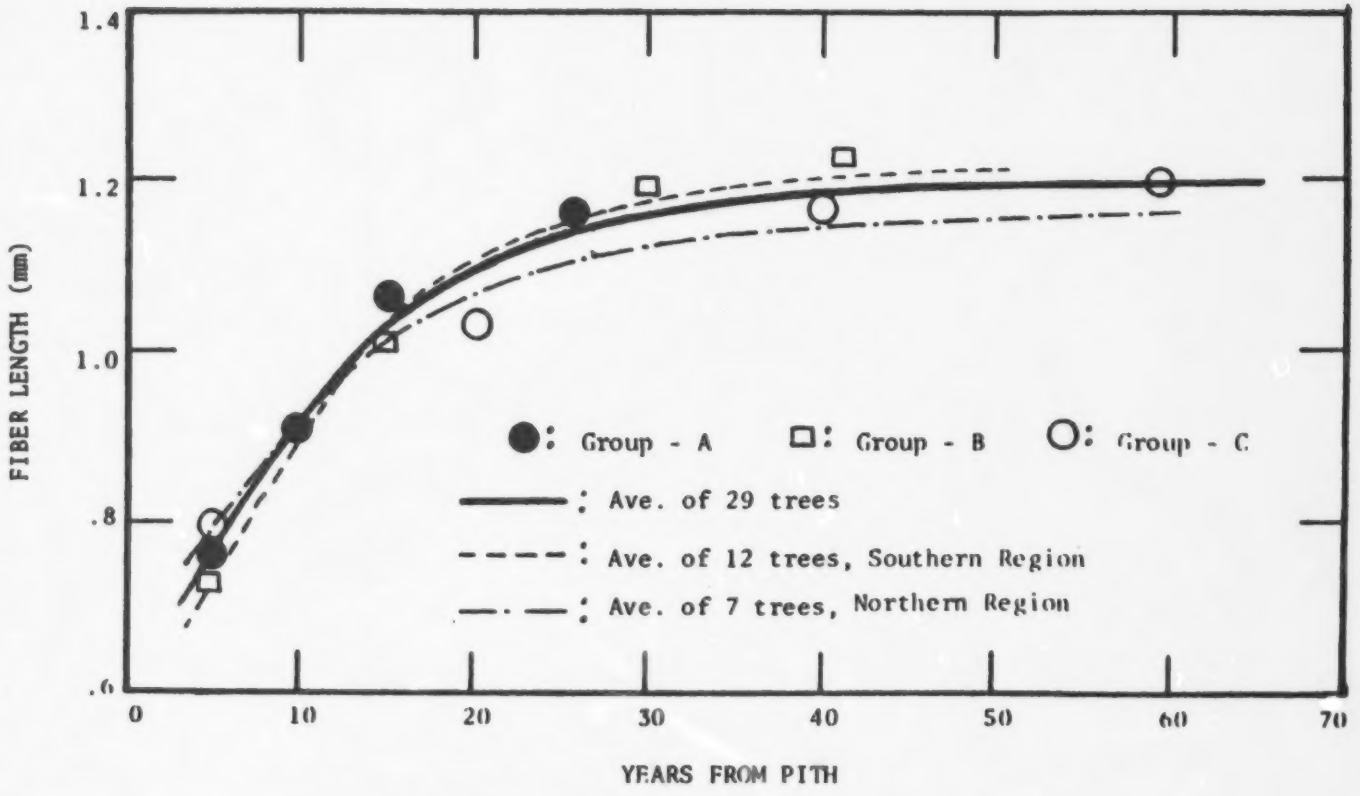


Figure 6 . Effects of age group and growth region on the relationship between fiber length and years from pith.

Note: The southern and northern region are represented by sample trees from Cambridge and Moosonee.

Group - A: Trees between 22-34 years (Ave. of 10 trees)
Group - B: Trees between 35-45 years (Ave. of 10 trees)
Group - C: Trees between 49-77 years (Ave. of 9 trees)

DISCUSSION II - T. Szabo, Moderator

MR. SZABO: So far I haven't heard from anybody who tried to relate all these measurements to actual volume indications. Which technique would be the best to give a volume estimate for a log or a tree. Could we do such a thing like that?

DR. SWANSON: Well, I think we're looking at volume. That technology exists. These technologies, at least that I've been talking about, are aimed at trying to learn something about internal characteristics.

To determine the volume, you want to know the shape -- the external shape of the tree or the log or the stem and we have scanners that can do that for us, so that's not a challenge.

MR. SZABO: Have you tried to come up with a volume indicator equation for a tree or a log in terms of certain end products other than lumber?

DR. SWANSON: No, I haven't.

MR. SZABO: Is there any idea of how some of these techniques could be incorporated into inventory assessment which would reflect certain end uses?

DR. CHOW: I think the problem is fairly complicated here and each instrument has its limitations. You have to select the parameter which can transmit the signal through the whole volume of the body of the wood to give it indications. The stress-wave field is good, but the problem is the parameters inference. For example, the moisture content or the outside preference of the stress wave or the wave travel into the area, consequently causing the accuracy problems. So I would say, yes, you can measure a total volume but the degree of accuracy varies, and for products the answer is no.

I just listened to Dr. Basham mention that the approach to the complex biological material, you have to deal with a population concept rather than single sample concepts. For example, you might be able to get some kind of a linear relation among 30 tree samples, but of individual ones, probably you would produce enormous scattering results.

MR. SZABO: It seems that research is taking one direction trying to measure things down the road; on the other hand, I see industry seeking some other information. I just don't see the correlation between the two. Let's take Mr. Norm Anderson's presentation. In my opinion he only would like to know how much clear wafer is in the tree or per hectare. How do we give some practical answers to him?

DR. CHOW: Well, I think there is no easy solution for this problem. You have to have a forester specialized in aspen. He needs experience and he also has to have a portable instrument for measuring wood soundness in situ. So he can go through the forest and take a look at external characteristics and with some instrumentation help, he must come to some indication on soundness. There is no easy answer to say that equipment would answer all your questions. I don't think so.

DR. LOMAN: I'm wondering; the decay picture and the fungal populations, the shape of the decay, it's all so complex. It seems to be so difficult to predict it in any way.

Wouldn't it be better, if you're interested in a specific product, say, chopsticks, that you look at the healthy wood that's present in the forest because it's more predictable. Your densities are more predictable, your water content is more predictable, so that you can somehow go into a forest and say, yes, I have X number of cubic meters of blocks that I can make into chopsticks in this stand and it gives us a viable operation.

DR. SWANSON: The problem is that we don't have a reliable way today to go out into the woods and say that is a healthy tree when we talk about aspen.

DR. LOMAN: No, but what you're doing is you're looking at instrumentation possibilities to measure decay. Why not go after the healthy wood instead using some new or available instrumentation?

DR. SWANSON: Well, those instruments do the same thing. I mean, they do it to a healthy tree. In fact, it's a lot easier to detect healthy wood in things like x-rays than it is to try and determine what's rot or what's decaying.

DR. LOMAN: So for inventory purposes, maybe you should emphasize that.

DR. CHOW: Well, I think it's not as simple as you say, a total concept of probability in aspen because there is no so-called healthy aspen stand. The headache is that the distribution of the aspen decay is not systematic. It's random and that's the problem of dealing with instrumentation.

DR. BASHAM: To get back to the point raised by the Mr. Szabo, I think if you have an area or a region in the province that you have never looked at aspen decay, you might be able to say that in this age class, you should probably get between 40 and 80 percent of wood decay. After you do an intensive decay study in that region, sampling the number of trees that I've suggested, you wouldn't be able to say that, in that stand, you're going to get 73 percent decay. You might bring that 40 to 80 percent figure down to 50 to 70 percent, but you can't figure much more than that. Because, as Dr. Chow says, when you're dealing with biological things such as trees and fungi, there are so many variations that it's virtually impossible. You can just get general trends.

DR. NAVRATIL: Just returning to the original question, if we had an instrument which would determine volume of rot in standing trees, there is a very simple answer. There is no instrumentation available at this moment because all the instruments which are available measure rot or defects in one plane. You cannot even predict or make any wild estimate what is three or four or five feet above. You might, if you have a very good knowledge of rot development so you know that, as rot columns extend to certain heights, but that would be again based more or less on probability calculations and good biological knowledge of rot.

MR. SZABO: What I heard from the industry panel is that they really don't care too much about the volume. They are watching on the other side, the recovery in terms of product yield. So can we tie the two together?

DR. SWANSON: You're saying recovery studies and things like that?

MR. SZABO: Well, let's take pulp; we don't talk in cubic meters, but tons of pulp.

DR. SWANSON: No, I think you're right. I think some work needs to be done in this area.

MR. SZABO: Can these be correlated to product yield or something useful to specific forest products utilization?

DR. CHOW: I think the interesting problem is like this morning, several times, Mr. Breck and Mr. Anderson mentioned high transportation costs involved in transporting the useless decayed wood. So the yield factor is extremely important.

DR. CYR: Nancy Cyr from Alberta Research Council.

I just wanted to comment on the very simplistic, but academic NMR. Essentially you look at the two-dimensional at one slice, but if you slice them in different directions you integrate the volume. So eventually, hopefully, if we do the correlation at so many slices at different heights, then we can calculate the volume of decay.

MR. SZABO: So you're looking for a statistical correlation. Would this work?

DR. CYR: Yes, but my point is the gap is very, very wide and we must get closer and closer to connecting the gap between the academic and the practical. Eventually we should be able to connect it.

MR. SZABO: Dr. Swanson, our NMR specialist, do you have any comments?

DR. SWANSON: Well, what she's saying is absolutely true. Some of the things that we're thinking about right now -- because it's the three-dimensional situation that we're really interested in -- the fast imaging techniques that are being used today in medicine are being used to look at flow of things like blood in the human body.

We're thinking about using that fast scanning equipment, and we don't have any flow in our log so we would let the log move at a very rapid rate and take those fast scans and actually, in that way, be able to put together a three-dimensional picture.

MR. BRECK: I was just wondering, it looked like we had two independent things we're looking at here. One is some

measure of volumes for predicting, say, long-term trends or relationships between fungus attack and age groups and the other is a point in time where someone in the forest has got to make a decision on cutting or not.

These are independent problems which might have the same technique or may not. But the latter one is what all the industry people want to know right away. I'm pulling a log into my operation. Should I pull it in or should I leave it out there? And you need to know, for planning purposes and for optimization of forest management, that a forest stand has got potential for this end user and that end user and my extraction techniques should be similar.

Now I have a question. This is an extremely large problem and it's not just unique to Alberta. It's unique to the whole industry whether it's in Russia or whether it's in the United States, Minnesota, or here, it's a common one and it seems to me there is a thread going through the way people look at it. What's the limitation to the development of these techniques? Is the limitation time? Is the limitation other industries where we're getting these technologies? Is the limitation money; that we're not putting the money into that type of research in order to develop at the speed that we need?

What's our limiting factor?

DR. SWANSON: Certainly, the rapidity with which we can develop useable technologies in any of these areas is definitely a function of the amount of resources that we're willing to commit and there is no doubt that doing research in a field like nuclear magnetic resonance is very costly. It's a very costly area.

I attended an international conference in Norway 2 years ago in which a group of researchers from around the world who were all interested in this type of technology came to the conclusion that it was too expensive for any one of the countries to possibly take it on, and that included the United States who was there in force. There was a great deal of encouragement for international cooperation in that area but since that conference, we've all gone back and we're working in our own little laboratories and we're attempting to try and develop cooperative and collaborative programs with others that have the interest to get more resources into the thing, but it doesn't go as fast as you would like.

MR. ANDERSON: We're talking about some pretty idealist situations here to measure the rot content in the stand and the moisture to the nearest hundred percent, accurately 19 out of 20 times or something like this when, really, operationally we don't even have inventories that can tell us what the gross volumes are in the conifer or aspen. We're in the infancy of aspen utilization in the province and in our area at least we're dealing with a very, very important resource.

We have got a lot of stands that are over 30 percent, many are over 40 percent rot content on the average. I think one of the things that we should be doing is working together to see how we can economically harvest some of those stands.

We know that the sound aspen wood is a good resource. It's a good raw material source for OSB and waferboard for example. From a management point of view it's great. It's got no reforestation costs. And the root system is alive so it's good for maintaining the quality of the soil, minimizes erosion, and, I believe, as one of the people showed this morning from Minnesota, it's a great species for wildlife because it regenerates the same season and solves a lot of problems the same season it's logged.

I think we should get back to how we can harvest literally tens of thousands or millions of acres out there that we know are heavily decayed. And the way we can do those things together is to create some flexibility in the operating conditions. Why have two-pass harvesting systems? And why does the forest industry have more restrictive road weight legislation than most other industries?

I think those are, in the short term, the objectives that we should be dealing with.

MR. GOFF: Lorne Goff, Alberta Forest Service.

Just from a slightly different perspective, I would like to ask the researchers what the potential might be for preventing the high rate of disease of this particular species?

DR. SWANSON: That's a very good question, and I think there is work being done on that. Some of it was alluded to here today. But there are some possibilities along these lines, using biotechnology that's just under development.

DR. NAVRATIL: Well, I cannot speak on the biotechnology item, but I think that as a researcher, we have enough knowledge, at least at times, to develop strategies on how to grow aspen with a higher quality and a low volume of defects.

I recently checked Russian literature and their thinning strategy seems to work very well in terms of decreasing volume of rot by Fomes igniarius.

I think thinning is one of the tools which we might utilize very well to our advantage. And in sanitary thinning, we can control density by thinning which means we can control natural protein to a certain degree, and we can control even the clonal composition by thinning, provided that the clones are really intermingled.

We don't have any specific techniques that will definitely provide higher quality stands. But I think there are some trends which we should follow up on and we should try at least to intensify research in those areas that we could develop the technique and procedures how to grow high quality stands.

DR. SWANSON: There have been some micro-organisms isolated that feed on things like F. igniarius and it's possible that it could be controlled biologically.

I also know that there is one research group in the detection area that's developed a technique for detecting antibodies that the tree produces when it's infected and it produces specific antibodies for almost any kind of infection that gets into it, just as any other organism does, and those can be detected. You can know by doing those kinds of analyses on a tree that it is infected and with what organisms it's infected long before there is any kind of physical manifestation of the infection.

DR. BASHAM: There are some promising leads in the area of biological control. There aren't any really good results yet that we can pinpoint, but at Sault St. Marie we have a researcher who was looking at microorganisms that occur in aspen and other trees that do inhibit the growth of F. igniarius and these other decay-causing fungi in the lab in petri dishes.

They show a great deal of promise. The problem is to get these organisms in the living tree using a method that is not too

costly. There's also second-growth aspen stands where you have stands coming up following fire or cut-over, and I think there is a good opportunity there to control the extent of Armillaria decay in the root systems. We're finding out more and more about Armillaria. We always thought it was one species; now we know it's at least six or seven. Some are very virulent, others avirulent.

One promising avenue is to introduce the non-virulent types of Armillaria into the soil and get them to get into the root system of aspen and keep the virulent Armillaria out. There are all kinds of promising leads in this area of biological control.

MR. MCDONALD: Brian McDonald from Procter & Gamble. Listening to what Mr. Norm Denney said, I was having some of the same thoughts that really we don't know very much about aspen. I would give my research medal to Dr. Basham who said that the only real correlation we have is age, only it's specific to areas, and so we'd have to do 30 trees, in each age class in each stand to get a number. Mr. Norm Denney this morning said how hard it is to age, so we certainly need to find out better methods of aging aspen.

I think while we're waiting around for that to happen, we need to have very flexible management strategy and operating strategy as Mr. Denney talked about. I don't think we can have it the same for all of Alberta. I think that's probably something we should consider very early in the game here.

MR. POND: Leon Pond, Weldwood of Canada. I'd just like to thank Mr. Smith and Mr. Dermott for getting this thing on because I think that the beginning of the solution is to have these kinds of meetings. Somebody in one of the panels this morning said that there was good correlation in the diversity of the results, and that's really saying that the problem is a mouthful.

I think that recognizing that decay is rampant in aspen is a big step towards us beginning to establish utilization and management practices that we can live with that will be economic to our businesses, and it is a different problem than managing softwood.

Our Company has been in the poplar aspen business now since 1965 or earlier, and our fellows that have been logging all those years still don't really know when you're going to run into those rotten trees. It's a very, very difficult thing, and frankly I

think that this type of meeting and recognizing the problem is the beginning of the solution, and I'd like to thank Mr. Smith and Mr. Dermott for getting this meeting going.

DR. BELLA: I don't know if I can add anything to these last comments. You already pretty well covered what I wanted to say. Actually, what Mr. Brian McDonald was saying earlier about the problem -- first of all, aspen decay is correlated with age and if we can determine age, then we're fairly far ahead already.

I suppose to that point, one should add that in Alberta, we have fairly good fire history maps, so that might be at least something of a starting point to use in aspen decay alleviation.

The other thing mentioned several times here was that there is fairly good correlation between age and decay, although there is a great deal of variation.

Now, I think, at least to my simple mind, it seemed that most of the problem we have at this time is because we have a lot of overmature stands. They have a fair amount of decay, so the problem is actually a management one, more than a research one to come up with some management guidelines and administrative guidelines to deal with these.

Now, the other thing is related to getting better inventories. Inventories are costly. Good inventories are very costly. Now, I'm sure you can get very good estimates of aspen decay or any kind of decay on a stand basis if you spend the money. As Dr. Basham pointed out earlier on, Wall nearly 15 or 20 years ago mentioned that one good way of sampling and finding out the amount of decay is do some line sampling. Can you do that in a stand? At this point I doubt if you have the money for that kind of detailed sampling.

So, again, I think the methods and the knowledge is there already. The fact is that we would have to spend a lot of money to get the kind of answers that you're seeking now.

PROCEEDINGS SUMMARY

Dr. W. R. Dempster
President
W.R. Dempster & Associates Ltd.

Well, I guess the last thing that everybody needs at this time of the day is a summary repeating what has already been said, so I will use that excuse to inject some rather personal perception into the day's proceedings.

It seems to me that underlying much of the interest in this workshop and much of the interest in aspen quality that has been expressed by the industry, is a certain level of anxiety. And why that anxiety is there I think has become somewhat clear today. Why should we have any anxiety when we're up to our ears in aspen; something like 900 million cubic meters. Fred McDougall once said that we have so much aspen that he once tried to sell some of it to the Texans, sending it down there by flume, and the only reason the deal didn't get through was he realized they were really after our water.

We've got lots of aspen. However, the reasons for our concerns about our aspen resource have really been discussed by the speakers so far today, but let me just make a couple of comments on what I think is fundamental to the problem.

And I think fundamental to our aspen problems are two underlying facts: One, much of the merchantable aspen that we are contending with in Alberta today originated from fires, large fires in the latter half of the 19th century and subsequent repeat burns. That means we've got a lot of stands that are now in the 80-year age bracket. We've also got younger material. But basically the merchantable material tends to be highly concentrated in that 80-year plus age. In conifers and softwoods, things are just getting going at that age. 80-year-old aspen is typically decaying.

We don't know much in terms of certainty, but in general we know that from that age on we've already got stain levels which may be prohibitive to CTMP development criteria that Mr. Breck discussed with us. We've got decay levels that are lifting off and possibly most important of all, we've got increasing instability of the stands.

And as Mr. Dan Breck alluded and a number of other speakers, we get hit by this sort of triple whammy as we get increased defect or as those stands become older and more unstable, we're contending with high delivered costs, lower product values and lower marketability.

So, we've got this age class problem, and as Mr. Dermott stressed, and I think it bears repeating, when we're talking about developments that we've got onstream at the moment, it's no good talking about what we might be able to do with future aspen stands, those developments are based on what we're stuck with out there now.

Secondly, and this hasn't been stressed today, it's been alluded to, but about 50 percent of the theoretical allowable cut is located more than 80 kilometres from potential manufacturing sites and that's based on a very optimistic definition of what constitutes a potential manufacturing site.

Hence, the concerns that have been discussed are somewhat justified. As various people have alluded to, some of the wood won't be there when we want it, some of it will cost too much to deliver, and some of it will not produce marketable products.

So much for the problem. What about needs, what can we do about it? Well, I had an Irish forestry professor who said that when you were confronted with anxiety, you should try and do something about it. It's rational human behaviour to try and reduce anxiety. To that effect, every morning when he woke up, he assured his wife that he loved her, and every morning when she woke up, she assured him that the Guinness brewery was not on strike.

What can we do to reduce the sort of anxiety that's been expressed by industrial managers of aspen today? First of all, let me address a few comments to the research foresters. I'm tempted to tell you what we don't need in the way of forestry research if we're going to address this problem immediately, but a lot of my friends are silviculturists and genetisists, so I won't say too much on that. I'm glad though that a couple of people today, for example, mentioned that it maybe isn't worth pursuing too vigorously clonal management and so on.

Decay and occurrence in forecasting was basically summarized by Drs. Basham and Navratil. I think that managers have to be clear as to what type of decisions we're trying to use this information for. That way we can avoid a lot of the dead-ends that that sort of research has in terms of what useful information it provides us.

I'm not too concerned about our ability or lack thereof to predict or assess decay in the individual tree or even the

individual stand. I think the best indicator of decay in aspen that we have right now and that we might not be able to improve on is the logging contractor that's paid on the basis of net scale. We do need, fairly desperately given the age class distribution that we're contending with, a better understanding of how long existing mature stands will remain economically operable. We can determine whether they're economically operable now, but how long are they going to remain that way; this is a probablistic problem. Just by looking at decay in surviving stands won't necessarily give us a handle on that.

This is really reiterating what various people have said, including Mr. Norm Denney when he said that he needs the best possible understanding of that stuff that he's got out there now that makes up 80 percent or so of the land base that's already mature; how long has he got to schedule that? We need the best possible scientific understanding of the dynamics of aspen stand deterioration and breakup. I don't believe that, in spite of the all the research that's been done in decay studies, that we have that answer.

Dr. Bella pointed out that, really fundamentally, this is a management problem. It's been said that in large aspen holdings, many of which lack even the crudest aspen management, much could be achieved by practical extensive management based on careful but simple regulation of age classes. That was also said 40 years ago, almost exactly, with regards to the Lake States.

Before you say, we do that, let me point out that some of the more important timber development areas I've been involved in don't have adequate age class information. I agree with Dr. Bella that we shouldn't immediately apply panic and the expenditure of large sums of money. I think if we pay more attention to the broad picture and fire origins rather than worrying too much about the individual stands and sticking every tree with an increment borer, we can resolve some of that fairly cost effectively.

We need broad but meaningful age class information, and we have to combine that with a better understanding of stand stability. There's no point in getting one without the other. We've got a similar situation to that which was described in Minnesota, although the actual age and dynamics are different. Because we've got this age class structure, the big problem is trying to hold wood on the stump and the question is, how long can we do that? Age then becomes the critical parameter in forest management, as several people have alluded to.

We need a better understanding of deterioration and breakup and the associated decay levels and the associated economic operability, and we need the age information to go along with it. Once we've got that, I think we can confront the foresters with some meaningful decision makers and put the problem where it should be, in the hands of the managers.

There will be some difficult decisions. Foresters, as we heard this morning, don't want to by-pass old stands. Yields may not be sustainable in certain areas. What do you do in that case? What can be done with the stuff that we can't utilize? There is wood out there that we certainly cannot utilize given current technology, and of course, this is a dynamic situation. We've been talking this afternoon as though this is a static thing. Deterioration of aspen is not a static situation.

Nevertheless, Mr. Allan Jones did raise an interesting prospect, that of recycling some of these old aspen stands that we can't utilize, providing an opportunity for employment in the process and, of course, passing the cost of that to the Wildlife Division.

We cannot ignore the realities of the marketplace as has been stated today, and I make no apologies for re-emphasizing that. The market is the driving force, and we better realize that however much, as foresters, we adhor having to recognize it; some of our wood is not merchantable.

Just as much as we can not ignore the realities of the age class distribution, we have to pay attention to the marketplace. And to be brief, foresters, developers of the resource, and manufacturers, I think it's become apparent today only a better appreciation of what wood quality criteria dictate the marketability of particular products. Forest industry development without application and quantification of the sort of trade-off that Mr. Breck was talking about this morning will inevitably result in the repetition of previous mistakes that we've seen in attempts at aspen development, but they're going to be on a bigger scale this time.

In summary, I will just reiterate what Mr. Terry Barr said, that really only a proportion of the allowable cut is likely to be successfully utilized in a competitive marketplace. If you can accept that as the basic problem, then I think it becomes clear that the need is to define which aspen can be used with least investment risk and the best chance of success. And, of course,

that poses a bunch of other decisions such as what are you going to do with the rest and so on.

To try and be a little positive and specific, I think we can certainly usefully invest in three information areas: one, the forest researchers can at least make sure that we've got the best possible understanding of this problem of aspen deterioration in the sort of stands that we're scheduling into our current developments. Secondly, we do need to improve the age information and our age management. We have to recognize the reality of that. And finally, and this is a broad undertaking, we need to clarify the quality requirements for particular end uses. We need to get a better handle on the parameters constituting that graph that Mr. Breck showed us this morning in which, of course, a concept applies to all of your products ultimately.

To put a final positive note on this, and to echo what Mr. Leon Pond said, part of the solution is recognizing the problem, and I think that's what's happening today.

CLOSING REMARKS

Mr. C. Dermott
Director
Timber Management Branch
Alberta Forest Service

In closing, I think the common thread in the seminar was that the industry and Forest Service land managers were very strong in pointing out their concerns or the problems they have with managing the aspen resource.

We in the Forest Service don't want to go off by ourself and try and resolve problems when you are the real people that are having those problems in trying to manage that resource. I think those problems were brought out very clearly and we will continue to work with the industry to try and resolve those problems; whether it's in management so that we can be more flexible, or whether it's research so that we can do a better job.

We try to look at industry's concerns, and I think these seminars help bring those out. We try to look at them when we develop the ground rules for harvesting or operating of the aspen; we develop them in conjunction with industry. We do not develop them ourselves. We get the support of industry so that we can proceed on a cooperative effort. We call the developed ground rules guidelines, so that they are flexible.

I think there have been many items pointed out that we have to go back and look at. We may have to adjust our management strategy, but I think at the same time there are two sides. First, we'd like to utilize 100 percent of the resource, and secondly, I guess it's the old term we called "high-grade." Someplace we've got to come in between, and I think that's what we're trying to strive for with this particular Workshop.

It's not all forest management concerns, and we won't be able to solve all our problems with forest management, as Dr. Bella pointed out. I think we need research so that we can do a better job of our forest management, and in particular, we need research in species identification. As Dr. Dempster has mentioned, another concern is the economic rotation or the cutting age of a particular stand. In utilization of poplar, industry has a very strong challenge.

To harvest some of the overdecandent stands, what is the economical base that Mr. Anderson mentioned? I think there's some research needed. It's a joint project. We have to look at the total management of our forest resource and see how we can best manage what Mother Nature left us. We have to proceed with research in many of the areas I've outlined.

Again, I would like to thank you all for coming, and I'd like you to join me again in giving the speakers a hand for the excellent presentations, and to you all for your valuable cooperation.

TOUR OF ARC'S FOREST PRODUCTS LABORATORIES

A permanent Forest Products and Forest Industrial Development Research Program was established at the Alberta Research Council on April 1, 1982, following recommendations by an advisory committee representing Alberta Energy & Natural Resources, Alberta Economic Development, the Alberta Research Council, Industry and the University of Alberta.

During 1982/1983, the Testing Laboratory was established at the Alberta Research Council's Parsons Property building in Millwoods; a number of strategic studies were initiated; and several research and development projects were begun, including design and construction of a prototype for machine stress rating full-size panels.

During 1983/84, the Testing Laboratory was expanded and it was accredited by Central Housing and Mortgage Corporation (CMHC); seven strategic studies were completed; and further research and development was carried out, including the development of a platen system for laboratory manufacture of corrugated waferboard.

During 1984/85, additional testing facilities were added; the Testing Laboratory was accredited, in principle, by Standards Council of Canada (SCC); initial equipment was acquired for the Panel Development Laboratory; and the two laboratories were moved to the new Alberta Research Council facilities at Mill Woods. Further strategic studies were commenced. Research and development continued.

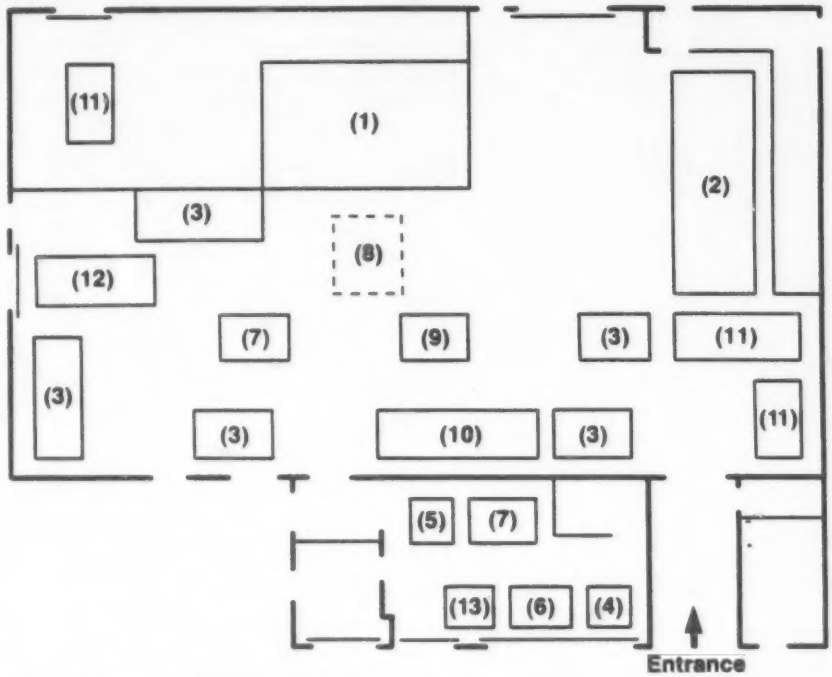
During 1985/86, the capabilities of the Testing Laboratory were expanded in the areas of performance testing and full-sized product evaluation; the Testing Laboratory received national accreditation from the Standards Council of Canada; and over $100,000 of contract testing was carried out for industry. During the year, the Canada Alberta Forest Resources Development Agreement funded acquisition of a 1220 mm X 2440 mm (4' X 8') press and auxiliary equipment from the dismantled Cancar-Kockums Panel Laboratory and initiated its installation in the Panel Development Laboratory at Mill Woods.

Forest Products Program

Guide to the

Testing Laboratory

Product evaluations are conducted for industrial clients and for the Forest Products Research Program. The laboratory has been certified by the Standards Council of Canada and Canada Mortgage and Housing Corporation.



Sample Preparation and Conditioning

Sample Preparation **(1)**

• Samples are cut, identified, weighed, measured and all data recorded.

Sample Conditioning

• The samples are stored in conditioning rooms under controlled temperature and humidity conditions to stabilize moisture content. **(2)** This is very important as the strength of wood depends on its moisture content.

• Boil tanks, vacuum and pressure vessel, steam tank, ovens, cooling baths and conditioning (soak) tank. **(3)** These provide various combinations of temperature and humidity that, when applied in cycles, simulate actual exposure to the weather. The ovens are also used to dry the samples which aids in determining moisture content.

Small Sample Testing

Instron Universal Testing Machine **(4)**

• Samples are subjected to bending or tension forces to calculate Modulus of Rupture (MOR) and Modulus of Elasticity (MOE) or Internal Bond.

Globe Shear Tester **(5)**

• Samples are subjected to shear forces to determine internal shear stresses at the failure load.

Vibration Testing **(6)**

• Samples are subjected to a vibrating force and their resonance is measured. The samples' stiffness and MOE are then calculated.

Linear Expansion **(7)**

• Samples that have been subjected to varying temperature and humidity conditions can be checked for dimensional stability (swelling).

Creep Tests **(8)**

• Samples are loaded continuously for long periods of time. Deflection is measured as a function of time.

Large Sample Testing

Machine Stress Rating (MSR) **(9)**

• A method that determines a panel's stiffness by nondestructive methods. This test apparatus can be installed in-line in a manufacturing plant to grade all panels in terms of strength and stiffness.

Post Flexure Machine **(10)**

• Full-size panels are subjected to a pure moment to calculate MOE and MOR. The testing conforms to ASTM D3043.

A.P.A. Test Floor **(11)**

• These two setups conform to A.P.A. standards. The test floors simulate both static and impact concentrated loads on an actual floor or roof panel component.

Stressed Skin Tester **(12)**

• A test apparatus which subjects the stressed skin panel to either a uniformly distributed load or a series of point loads. The MOR and MOE of the panel are calculated from the data collected.

Data Processing and Management

Recording Data **(13)**

• Personal computers are used to record data, reducing human error. However, before the output from the electronic measuring device is sent to the computer, a visual verification is made by a technologist.

Reporting Data

• A spread sheet program calculates all necessary sample properties from the input data and produces a table suitable for inserting into a formal report.

For further information

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ALBERTA RESEARCH COUNCIL

Forest Products Program

Guide to the

Panel Development Laboratory

This laboratory is equipped with four panel presses for the research and development (R&D) of panel products. These facilities are available for use by and for industrial clients as well as in-house R&D.

The laboratory presses and auxiliary equipment are capable of processing chips, wafers, strands and fibrous wood materials from the reduced form (chips, fibres, etc.) to the finished panel. Testing of the product according to various specifications such as ASTM or CSA can then be carried out in-house by the Testing Laboratory.

Chip or Fibre Preparation

Drying and preparation

- A large walk-in (electrically heated) drying oven with a six tray wheel rack is available for drying the raw materials. **(1)**
- Two sizes of shaker screens for grading chip or stranded wood are available. One unit is 30″ × 30″ while the other is a pilot size 24″ × 72″ unit. **(2)**
- Two resin blenders for adding wax and resins to the furnish are available. These units are drum type blenders which can be fitted with a hot wax spraying apparatus.
- One of the blenders is for use with a powder resin **(3)**,while the second is a pilot-scale liquid resin blender fitted with a spinning disc liquid resin distributor. **(4)**

Mat Formers and Presses

The four presses in the laboratory are graded in size so that development work can be conducted from a small scale preliminary investigation to the full-size panel product level. The equipment includes:

- A 12″ × 12″ electrically heated hydraulic press capable of producing 100 tons of force or 1100 psi on a 12″ × 12″ board. The mat is either laid up by hand for this unit or it may be produced on a mat former and cut to size. **(5)**

Programmable controls are used in the unit for product reproducibility.

- A 28″ × 52″ electrically heated hydraulic press with a capacity of 500 tons force or 680 psi on a 28″ × 52″ pressed board. **(6a)**

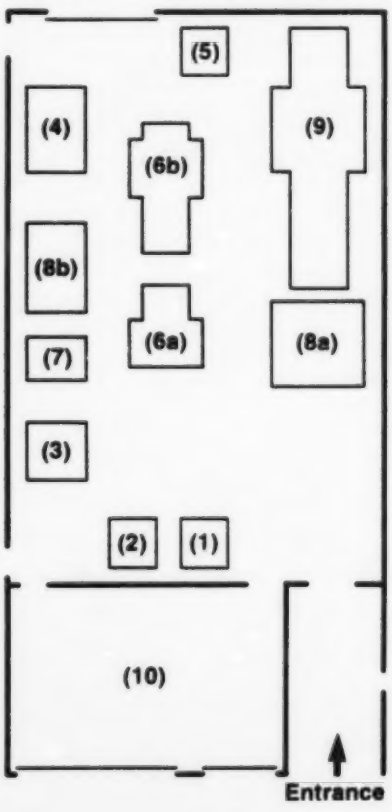
Programmable controls for heat, pressure, displacement and time are used on this unit in order to permit reproducible cycles.

This unit includes a former with picker rolls similar to a plant unit which produces a random orientation. It also has a removable orienter which can orient the strands in a crosswise direction. Longitudinal orientation can be attained by changing the orientation of the caul plate (perpendicular to the rolls).**(6b)** Variable speed drives are used on the metering belt, picker rolls, orienting heads, and caul drive.

A weigh scale is mounted on the caul drive so that continuous weight monitoring can be conducted for reproducibility.

- A 34″ × 34″ steam heated hydraulic press with a capacity of 380 tons or 660 psi on a 34″ × 34″ pressed board. This unit is fitted with platens which can be used to inject steam into the mat. The mat can be formed by hand or on the former associated with the 28″ × 52″ press. **(7)**
- A 4′ × 8′ (nominal) hydraulic press with a capacity of 2000 tons or 660 psi on a 58″ × 104″ pressed board. **(8a)**This unit is heated by steam produced on a 150 kW steam boiler with a capacity of 600 psi saturated steam. **(8b)**

The furnish may be formed in a random waferboard or an oriented strandboard with an orienter **(9)** similar to that used in Alberta OSB plants. All motor drives on the former and orienter are variable speed to give flexibility in selecting conditions.



A small laboratory **(10)** is associated with this area where small-scale testing of the products can be conducted. However, full-scale testing of the product can also be done in the testing laboratory

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